

**MINISTRY OF SCIENCE AND HIGHER EDUCATION
RUSSIAN FEDERATION**

**FEDERAL STATE AUTONOMOUS EDUCATIONAL INSTITUTION OF
HIGHER EDUCATION
NORTH-CAUCASUS FEDERAL UNIVERSITY**

Methodological Guidelines
for Students on arranging and performing laboratory works
in the Discipline of Biology:Cytology
for Students majoring (Specialty) in 31.05.01 General Medicine

Date: _____

**TOPIC 1: BASIC METHODS FOR STUDYING CELL STRUCTURE AND FUNCTION:
LIGHT AND ELECTRON MICROSCOPY**

I. INDEPENDENT STUDENT WORK IN PREPARATION FOR THE CLASS:

Familiarize yourself with the rules for preparing and formatting laboratory works:

1. Each laboratory work consists of two main blocks: independent student work in preparation for the class and classroom work. The first block contains the volume of theoretical material recommended for review in the form of a list of questions or links to necessary literature. It ends with a block of basic-level test tasks.

Classroom work is carried out in stages in accordance with the numbering of the works. For each, we determine and record the objective, familiarize ourselves with the procedure, record the necessary data, and formulate conclusions and answers to the posed questions.

Each laboratory work is evaluated and signed by the teacher, indicating the date of submission of the specific work. If the work does not meet the requirements, it must be retaken. Work without a teacher's signature is considered incomplete.

2. When drawing and depicting biological objects, it is necessary to have a set of colored and simple pencils at hand. The drawing itself should be large in size, with its details clearly visible. An important aspect of the drawing is the representation of the shape and proportions of individual parts as well as the entire object. It is not necessary to indicate the contours of the field of view of the microscope. For each drawing, it is necessary to provide information about the parts of the depicted object. For individual parts, arrows are used to clearly indicate the specific structures of the object. In addition, the name or number of each part is also indicated. In the case of numbers, a note is provided to explain the numerical designation. Under each drawing, additional information is provided, such as the magnification of the microscope, any colorings applied to the specimen, and the fixative used to preserve the biological sample. In the titles of the works and drawings, it is necessary to use the Latin names of the objects involved (as indicated).

Work 1.1. Research methods used in cytology.

Objective

Task 1.1 Analyze the basic methods of studying the cell. Consider the main research objectives and principles of these methods. Fill in Table 1.

Table 1

CHARACTERISTICS OF CYTOLOGICAL RESEARCH METHODS

No.	Name	Objective	Principle
1	Vital microscopy		
2	Fixed cell microscopy		
3	Cytophotometry		
4	Fractional centrifugation		
5	Autoradiography		
6	Cell culture		

7	<i>Somatic cell hybridization</i>		
8	<i>Electron microscopy</i>		

II. CLASSROOM WORK:

Work 1.2. Structure of the light microscope.

Objective

Task 1.2.1. Examine the figure. Write down the name of each part corresponding to the indicated numbers, reflecting the features of the external structure of the light microscope.



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The mechanical part of the microscope includes:

Purpose:

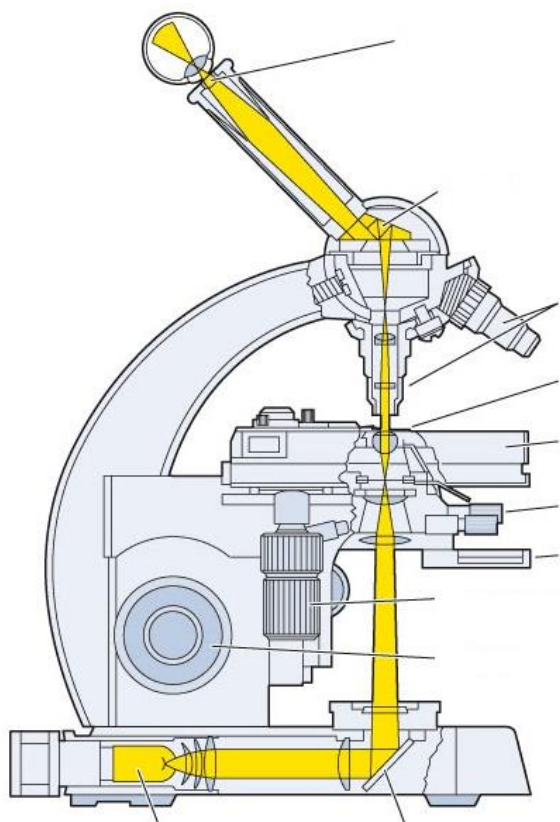
The optical part includes:

Purpose:

The illuminating part includes:

Purpose:

Task 1.2.2. Examine the figure. Write down the name of each part corresponding to the indicated numbers, reflecting the features of the internal structure of the light microscope.



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Rules for working with the Micromed R1 LED (Micromed-5) microscope

1. Place the microscope in front of you so that its mirror faces the light source. 2. Fully open the diaphragm, and raise the condenser to its highest position.
3. Work with a microscope should always begin with low magnification. Put the low magnification objective (x8 or x10) into the working position. To do this, turn the revolving nosepiece until the desired objective takes a central position relative to the tube and the stage (stands above the stage opening). When the nosepiece clicks into place, a light click is heard.
4. Using the coarse adjustment knob, raise the objective above the stage to a height of approximately 1 cm.

5. Adjust the lighting in the field of view of the microscope using the electric illuminator or mirror. Looking into the eyepiece with your eye, rotate the mirror with the concave side in different directions until the field of view is brightly and evenly illuminated.

If the microscope is equipped with an illuminator, connect the microscope to the power source, turn on the lamp, and set the required brightness.

6. Place the slide on the stage with the coverslip facing up so that the object being studied is under the objective and in the center of the stage opening.

7. Looking from the side, lower the objective using the coarse knob until the distance between the lower lens of the objective and the microslide is 4–5 mm.

8. Look into the eyepiece and at the same time slowly raise the tube/objective using the coarse adjustment knob until the image of the object appears in the field of view (the focal length for low magnification is approximately 1.0 cm).

* Attention! Do not look into the eyepiece while lowering the objective/tube to avoid crushing the coverslip of the slide and scratching the objective lens.

9. To study an object at high magnification, first, you need to place the selected area of the studied object in the center of the microscope's field of view at low magnification.

If the object is not centered, it will remain out of the field of view at high magnification. 10. Then, without raising the tube!, turn the nosepiece so that the high magnification objective x40 takes the working position over the slide. When the nosepiece is correctly fixed, a click is heard. The focal length for high magnification is 1 mm.

* Attention! When working with a high magnification objective, do not use the coarse knob to avoid damaging/crushing the coverslip.

11. To obtain a clear image of the object, use the fine adjustment knob.

12. If the image does not appear, you must repeat all the operations from steps 7, 8, 9, 10, 11.

13. After finishing work, remove the slide from the stage and wipe all parts of the microscope with a clean cloth,

14. The microscope is left in a neutral position. To do this, the nosepiece is turned so that the low and high magnification objectives are facing forward. The stand is lowered as much as possible using the coarse knob. This position of the microscope is the most stable and safe for the optical part. Cover the microscope with a plastic cover.

Total microscope magnification

is defined as the product of the objective magnification (V_{obj}) on the eyepiece magnification (V_{eye}):

$$V = V_{obj} \cdot V_{eye}$$

Work 1.3. Preparation of a temporary microslide of Tradescantia leaf epidermis

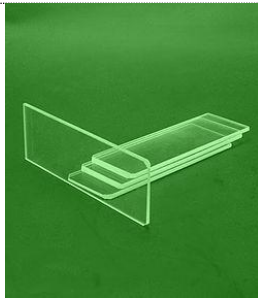
Procedure:

1. Take a glass slide, holding it by the side edges so as not to leave fingerprints on its surface, and place it on the table.

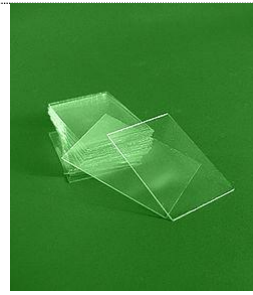
2. Place a drop of water on the glass slide.

3. Using a dissecting needle, remove the epidermis and place it in the water on the glass slide.

4. Take a coverslip by the side edges. Cover with the coverslip: place it at a 45° angle and release it sharply.



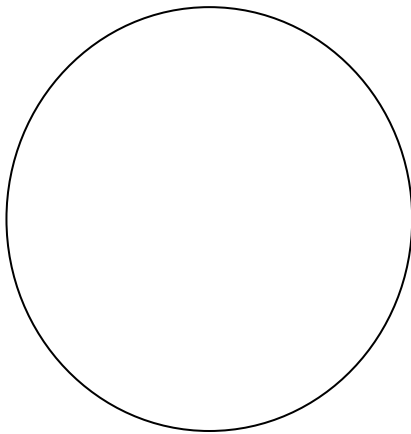
A) Slide glass



B) Cover glass

5. Examine the prepared slide under the microscope, first at low and then at high magnification.
6. Move the slide using the mechanical stage controls or your hands until you find an area where the stomata and part of the epidermis are clearly visible.
7. Draw what you see in the column of Table 1 below, strictly observing the size proportions (low magnification).
8. Then examine and draw what you see in the column of Table 2 below, the same area at high microscope magnification, after centering the slide (i.e., placing this area in the center of the field of view at low magnification).

Figure 1.



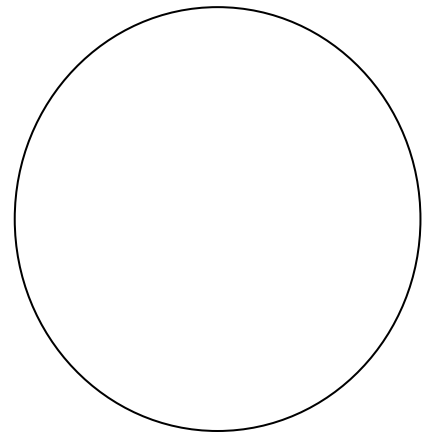
Magnification _____

Number of cells in the field of view _____

Epidermal cells _____

Stoma and its parts _____

Figure 2.



Magnification _____

Number of cells in the field of view _____

Epidermal cells _____

Stoma and its parts _____

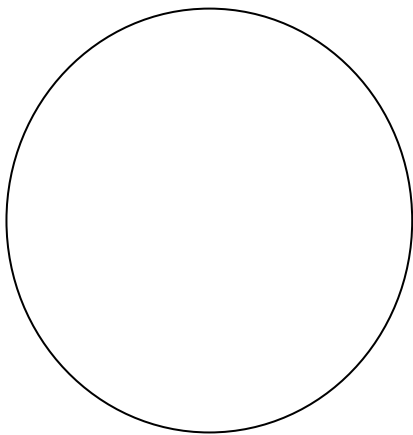
Work 1.4. Cotton fibers and air bubbles under the microscope.*Procedure:*

1. Take a glass slide, holding it by the side edges so as not to leave fingerprints on its surface, and place it on the table.
2. Place a drop of water on the glass slide.
3. Using tweezers, take a small tuft of cotton fibers from the Petri dish and place it in the center of the glass

slide.

4. Loosen with dissecting needles, achieving a thin arrangement of individual fibers.
5. Take a coverslip by the side edges and place it on top of the glass slide. 6. Examine the prepared slide under the microscope, first at low and then at high magnification, in stages.
7. Move the slide using the mechanical stage controls or your hands until you find an area where the fibers are sparsely distributed, and among them, there is a small air bubble.
8. Draw an air bubble and 2-3 cotton fibers surrounding it, strictly observing the size proportions in the column of Table 3 below.
9. Then examine and draw what you see in the column of Table 4 below, the same area at high microscope magnification, after centering the slide (i.e., placing this area in the center of the field of view at low magnification).

Figure 3.

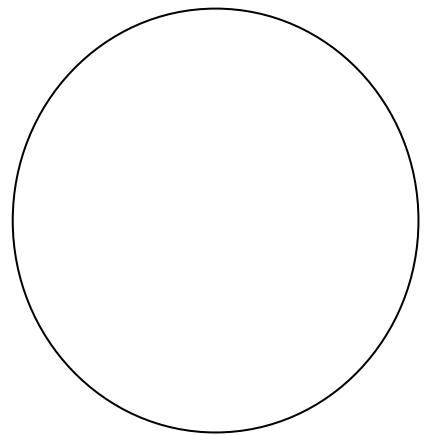


Magnification _____

Number of fibers in the field of view _____

Air bubbles _____

Figure 4.



Magnification _____

Number of fibers in the field of view _____

Air bubbles _____

INDEPENDENT STUDENT WORK to consolidate skills:

Task 1.1 A permanent slide is studied at low magnification, however, when switching to high magnification, the object is not visible, even with correction by the coarse and fine adjustment knobs and sufficient illumination. It is necessary to determine what this could be related to?

Task 1.2 The studied slide was damaged during work under low microscope magnification: the glass slide and coverslip were broken. Explain how this could have happened?

Task 1.3 The total magnification of the microscope during work is 280 in one case, and 900 in another. Explain which objectives and eyepieces were used in the first and second cases, and what objects they allow to study?

Task 1.4 The classroom has weak artificial light. The object is clearly visible at low magnification, but when attempting to examine it at x40 objective magnification, it is not visible; the field of view is partially illuminated. Determine what this could be related to?

Task 1.6 Despite the light source being turned on, the field of view in the microscope is dark at both low and high magnification. Indicate possible reasons.

Task 1.7 Find the corresponding pairs "Microscope element - functional part of the microscope" for each item given in the first column, select the corresponding item from the second column

MICROSCOPE ELEMENT:

FUNCTIONAL PART OF THE MICROSCOPE:

1. Revolving nosepiece
2. Diaphragm
3. Coarse adjustment knob
4. Condenser
5. Objective
6. Tube

A - OPTICAL
B - MECHANICAL
C - ILLUMINATING

ANSWER:

1	2	3	4	5	6

Task 1.8 Find the corresponding pairs "Microscope element - functional part of the microscope" for each item given in the first column, select the corresponding item from the second column

MICROSCOPE ELEMENT:

FUNCTIONAL PART OF THE MICROSCOPE:

1. Stage
2. Fine adjustment knob
3. Arm (Stand)
4. Eyepiece
5. Objective
6. Condenser

A - OPTICAL
B - MECHANICAL
C - ILLUMINATING

ANSWER:

1	2	3	4	5	6

Task 1.9 Determine the procedure for preparing the optical part of the microscope for operation. In the answer, write the necessary sequence of letters:

- A Position the objective using the coarse adjustment knob above the stage at a height of approximately 0.5 cm
- B Feel the catch engage; a soft click is heard, and the nosepiece is fixed in place
- C Place your hand on the coarse adjustment knob
- D Turn the revolving nosepiece until the low magnification objective is above the stage opening
- E Raise the nosepiece with objectives above the stage so that the objectives do not touch the stage when the nosepiece is rotated
- F Place your hand on the revolving nosepiece

ANSWER: _____

Task 1.10 Indicate the steps for preparing the microscope for non-working state. In the answer, write the necessary sequence of letters:

- A Remove the glass slide with the studied object from the stage
- B Turn off the light if the device has a built-in illuminating element
- C Place your hand on the revolving nosepiece
- D Wipe the glass and place it in the box with distributed educational materials
- E Turn the revolving nosepiece until the objectives are in a neutral position (no single objective is in a working state)
- F Cover the microscope with a cover

ANSWER: _____

Task 1.11 Determine the procedure for switching the microscope from low to high magnification. In the answer, write the necessary sequence of letters:

- A *Place your hand on the revolving nosepiece*
- B *Open the diaphragm and raise the condenser using the knob*
- C *Find the focus using the fine adjustment knob*
- D *Adjust the image focus at low magnification using the coarse adjustment knob*
- E *Turn the revolving nosepiece until the high magnification objective is above the stage opening*
- F *Position the required part of the studied object in the center*

ANSWER: _____

Grade for the class _____

Teacher's signature _____

Date _____

Date: _____

TOPIC 2: NON-CELLULAR FORMS OF LIFE

INDEPENDENT STUDENT WORK: PREPARATION FOR THE CLASS

Task 1.1 Give definitions for the terms:	
Cell -	
Prokaryotes -	
Eukaryotes -	
Viruses -	
Bacteriophage -	
Retrovirus -	
Capsid -	
Virion -	

For reference: Viruses (Lat. virus - poison) were discovered in 1892 by the Russian scientist D. I. Ivanovsky during the study of tobacco mosaic disease. Viruses are a transitional form between non-living and living matter. Each viral particle consists of RNA or DNA enclosed in a protein coat called a capsid. A fully formed infectious particle is called a virion. Some viruses (for example, herpes or flu) also have an additional lipoprotein envelope that arises from the plasma membrane of the host cell. Viruses are capable of reproducing only within the cells of other organisms. Outside the cells of organisms, they show no signs of life.

Basic level test tasks:

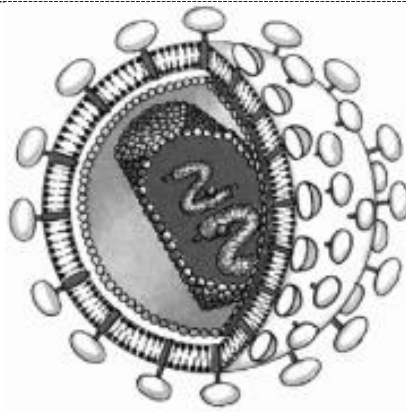
1. Choose three correct answers out of six and write the numbers under which they are indicated in the table.

Viruses:

- 1) do not have their own metabolism
- 2) are intracellular parasites
- 3) are able to reproduce only inside animal cells
- 4) do not contain nucleic acids
- 5) can be destroyed by the use of antibiotics
- 6) are not capable of independent protein synthesis

ANSWER: ____

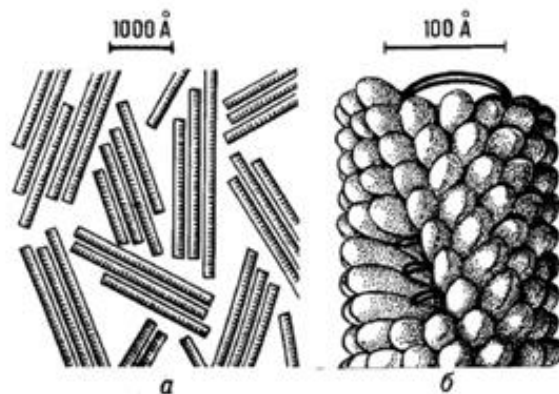
2. Choose three correct answers out of six and write down the numbers under which they are indicated. What features are characteristic of the biological object shown in the figure?



- 1) genetic material is represented by RNA molecules
- 2) cell wall made of murein
- 3) presence of small ribosomes
- 4) presence of a cell center
- 5) is the causative agent of AIDS
- 6) has an outer protein-lipid membrane

ANSWER: ____

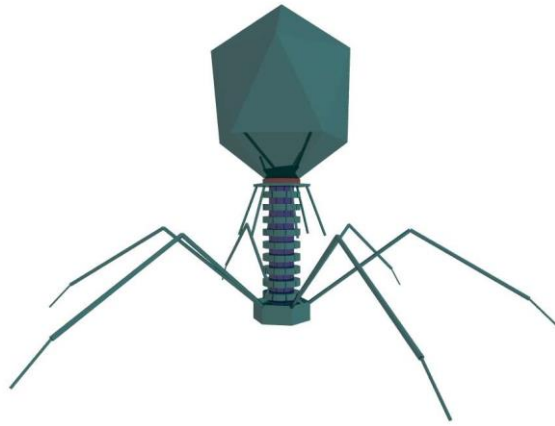
3. Choose three correct answers out of six and write down the numbers under which they are indicated. What features are attributed to the life form shown in the figure?



- 1) synthesis of ATP molecules
- 2) lack of own metabolism
- 3) spore formation
- 4) chemotrophic nutrition
- 5) parasitic lifestyle
- 6) protein capsid

ANSWER: ____

4. Examine the figure. (A) Name the object shown in the figure. (B) What chemical substances does it consist of? (C) What is the condition for the reproduction of this biological object? (D) What level of organization of life does it belong to? Write down the numbers in the order corresponding to the letters.



- 1) proteins, fats, carbohydrates
- 2) phage
- 3) proteins and nucleic acids
- 4) molecular
- 5) non-cellular
- 6) tobacco mosaic virus
- 7) positive temperatures and humidity
- 8) presence of a host cell

ANSWER: ____

5. Establish a correspondence between the trait of an organism and the group for which it is characteristic: 1) prokaryotes, 2) viruses.

- A) cellular body structure
- B) presence of own metabolism
- C) insertion of own DNA into host cell DNA
- D) consists of nucleic acid and protein coat
- E) reproduction by binary fission
- F) ability for reverse transcription

ANSWER: ____

6. Establish a correspondence between characteristics and natural objects: 1) viruses, 2) bacteria. Write the numbers 1 and 2 in the order corresponding to the letters.

- A) strictly parasitic lifestyle
- B) ability to synthesize protein molecules
- C) formation of spores to endure unfavorable environmental conditions
- D) lack of own metabolism
- E) presence of a cell wall
- F) division of the cell in two

ANSWER: ____

7. Find three errors in the given text "Viruses". Indicate the numbers of the sentences in which errors are made.

(1) Viruses are intracellular parasites, they show activity only in host cells. (2) Viruses belong to prokaryotes. (3) All viral particles consist of a DNA molecule and a cellulose coat. (4) Viruses have all the characteristics of living things: heredity, metabolism, irritability, and others. (5) Viral nucleic acids are synthesized from host nucleotides. (6) Viruses are causative agents of many dangerous diseases: flu, hepatitis, etc. (7) They can transfer genes between cells of one organism, between organisms of both the same and different species or even classes.

ANSWER: ____

8. Find three errors in the given text. Indicate the numbers of the sentences in which they are made.

(1) Viruses are intracellular parasites. (2) The genetic apparatus of all viruses is represented by a DNA molecule. (3) They synthesize their nucleic acids and proteins from the corresponding monomers of the host cell. (4) Viruses belong to prokaryotes. (5) The virus envelope is formed by a complex of polysaccharides. (6) Viruses are the causative agents of many dangerous diseases: rabies, hepatitis, etc. (7) Viruses parasitize in the cells of plants, animals, and humans. (8) A special group of viruses - bacteriophages - infects bacterial cells.

ANSWER: ____

9. Find three errors in the given text "Therapeutic sera". Indicate the numbers of the sentences in which the errors are made.

(1) Blood devoid of formed elements is called serum. (2) Therapeutic sera contain ready-made antibodies. (3) Therapeutic sera, like vaccines, are prepared on an industrial scale. (4) Such sera are used not only to prevent but also to treat infectious diseases. (5) Antibodies of therapeutic sera, unlike antibodies formed after vaccination in the human body, are lipids. (6) When therapeutic sera are introduced into the human body, an active artificial immunity is formed in it. (7) The introduction of therapeutic serum helps a person cope with diseases such as diphtheria and tetanus.

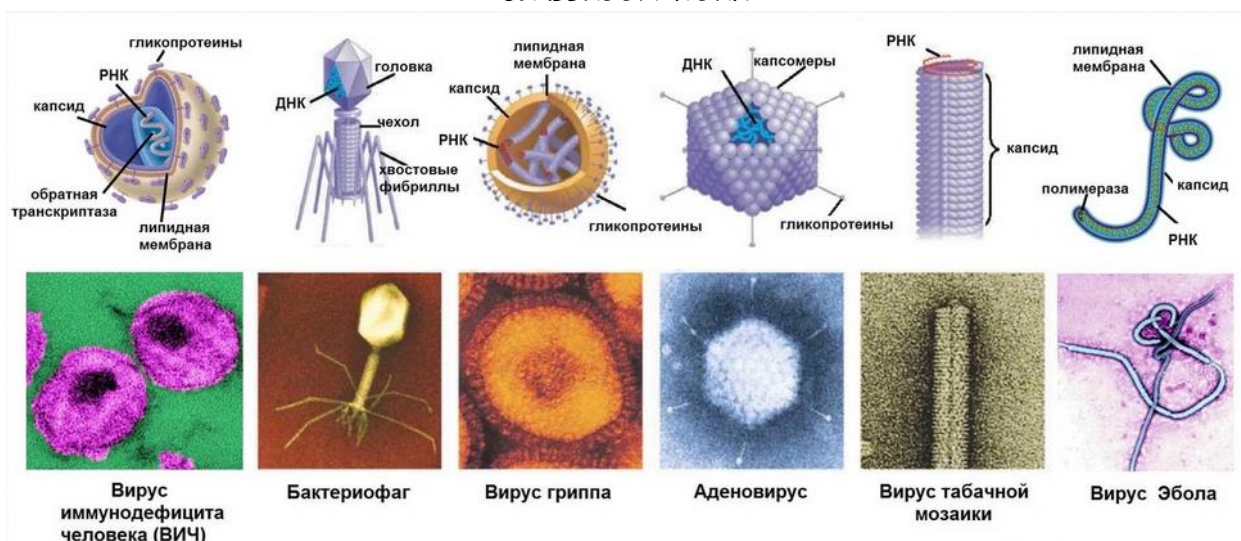
ANSWER: ____

10. It is known that viruses are smaller than bacteria, belong to a non-cellular life form, and are obligate parasites of living cells. Choose from the text below three statements that relate in meaning to the description of the traits highlighted above, and write down the numbers under which they are indicated.

(1) Viruses pass through bacterial filters and are visible only under an electron microscope. (2) Viruses consist only of a DNA or RNA molecule surrounded by a protein or protein-lipid capsid. (3) The shape of viruses is diverse: spherical, rod-shaped, filamentous, or polyhedral. (4) Most viruses have a symmetrical structure. (5) Viruses multiply inside the cell of another organism, and outside it, they are inert. (6) Viruses are able to transfer genetic information between cells within an organism and between different organisms.

ANSWER: ____

CLASSROOM WORK:



Task 2.4 Situational tasks:

TASK 1. A 23-year-old woman was admitted to the infectious diseases hospital with a rash on inflamed skin and genital mucosa. The rashes looked like grouped vesicles 0.1–0.3 cm in diameter. Some of them were eroded. The disease is accompanied by fever, pain, itching, and burning in the affected areas. A diagnosis was made: "Genital herpes". The antiviral drug Panavir was prescribed for treatment.

Task: Name the source and transmission routes of herpes. How did the patient get infected?

Your answer: _____

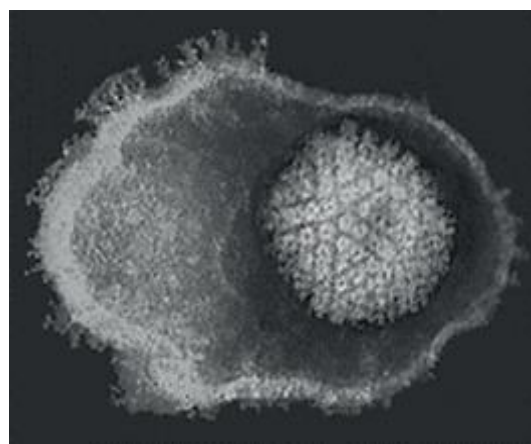
Task: Using the handout material, explain which stages of the virus life cycle the antiviral drug Panavir blocks.

Your answer: _____

Task: Draw a diagram of the structure of the herpes pathogen. The diagram should indicate:

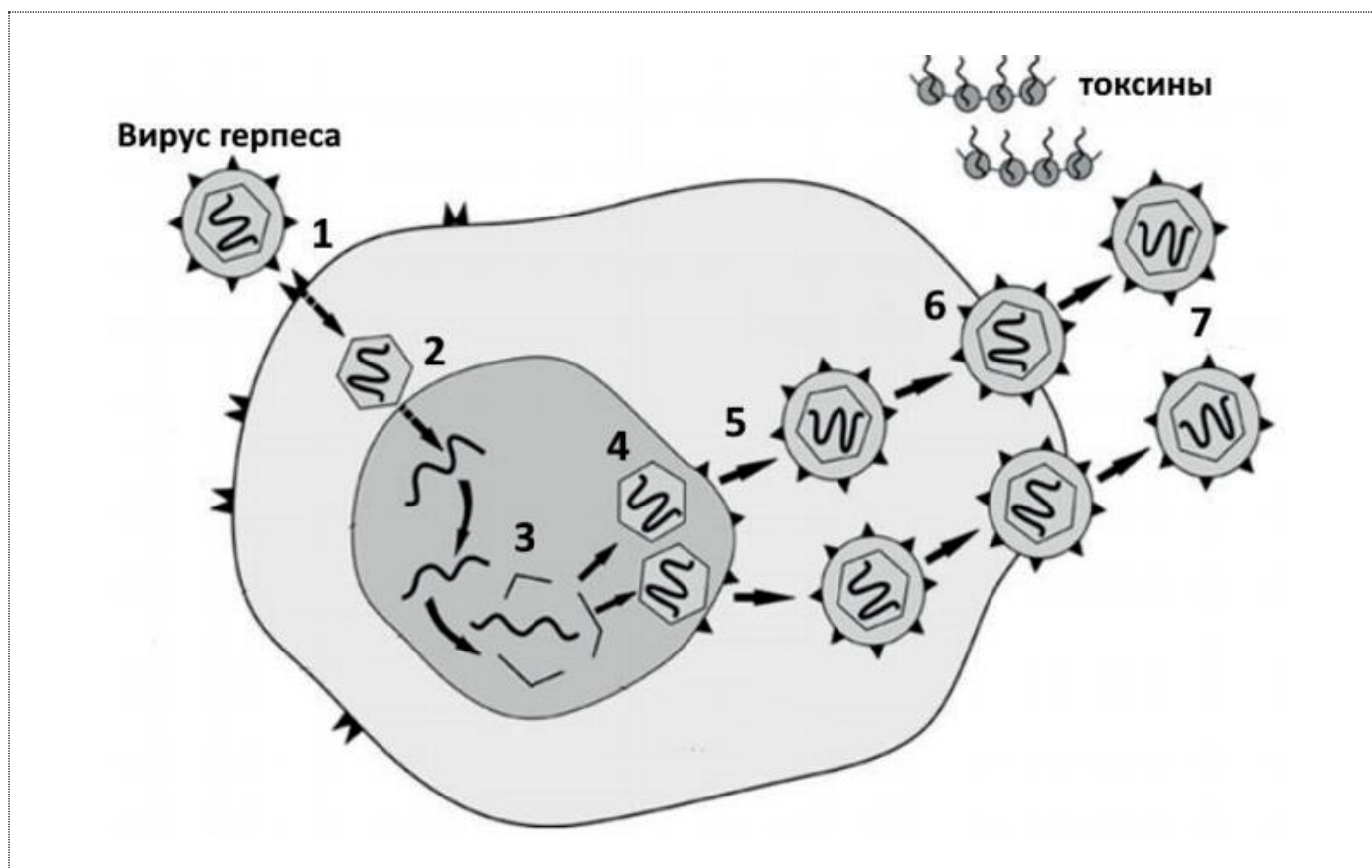
1 - nucleocapsid, 2 - genome (DNA), 3 - envelope, 4 - glycoprotein complex.

Figure-diagram 1. Structure of the herpes pathogen



Herpes virus under an electron microscope.

Task: Using the diagram, describe the stages of herpes virus reproduction:



For reference: Herpes virus. A distinctive feature of herpes viruses is the ability to stay hidden inside cells until a decrease in immunity provokes the transition of the virus to the next stage, in which it begins to multiply.

Infection occurs by the entry of virus particles onto the mucous membranes (mouth, nose, eyes, genitals) from a sick person. In children, getting on intact skin is enough. Having penetrated the body, the virus migrates along the nerve endings to the nerve cells (neurons), where it hides until favorable conditions arise.

Signs of herpes usually manifest as painful, itchy, small vesicular rashes filled with cloudy fluid.

Herpes on the lips and face is caused mainly by the herpes simplex virus type 1 (HSV-1), and sometimes type 2, transmitted through saliva and household contact. The cause of genital herpes is the herpes virus type 2 (HSV-2), which causes rashes on the genitals of men and women. It is transmitted from a sick person to a healthy one through unprotected sexual contact.

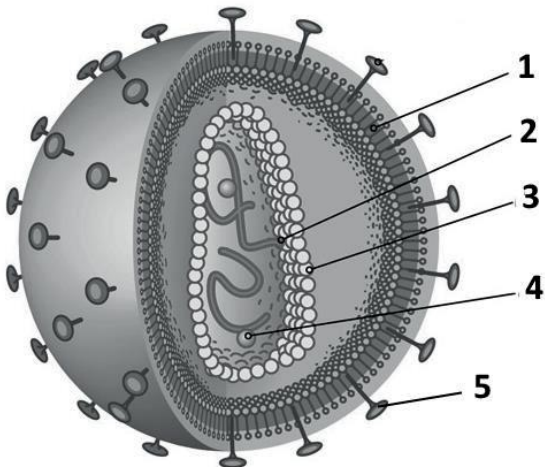
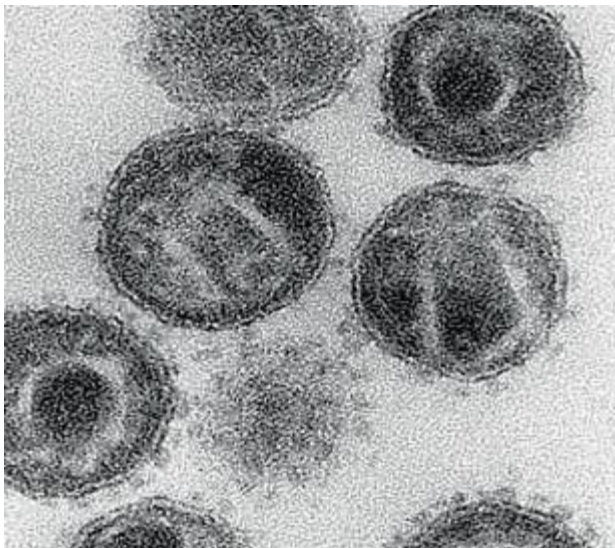
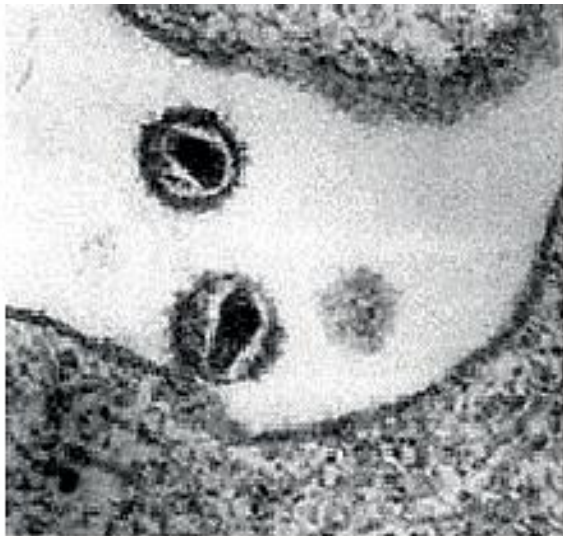


TASK 2. Patient K., aged 28, was admitted to the therapeutic department of the hospital for pneumonia. In the last six months, she has been frequently ill: recurring stomatitis, vaginal candidiasis ("thrush"), periodic exacerbation of furunculosis and herpes zoster. The patient has lost a lot of weight, notes growing weakness.

Laboratory test results: HIV test is positive, pneumonia is detected.

Preliminary diagnosis: "HIV infection"?

Task: Describe the structure of the HIV virus. Find the corresponding structures on the HIV virion diagram and, using the handout material, indicate their functions.

	indicate the corresponding number Capsid - Function - Supercapsid - Function - Glycoprotein - Function - Reverse transcriptase - Function - Virion RNA - Function -
Electron microscope image of HIV virions:	
	

Task: Using the diagram, describe the stages of HIV reproduction:

1 -
2 -
3 -
4 -
5 -
6 -
7 -

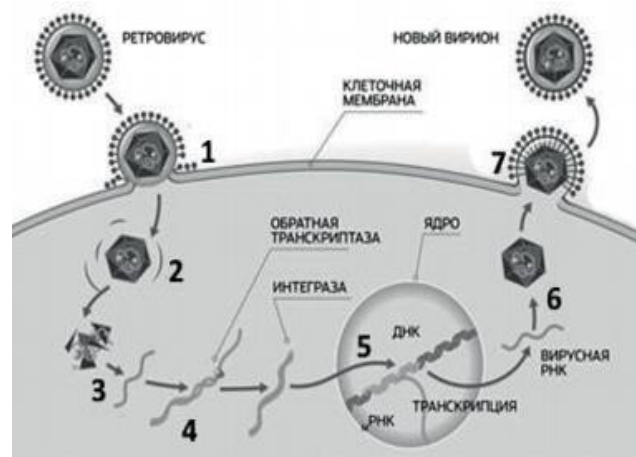


Diagram of HIV reproduction stages

For reference: Initially, the central dogma of molecular biology was formulated as:



However, a detailed study of the structure of viruses showed that in some of them, the genome is not DNA, as usual, but RNA. Such unusual viruses were called retroviruses (retro - reverse).

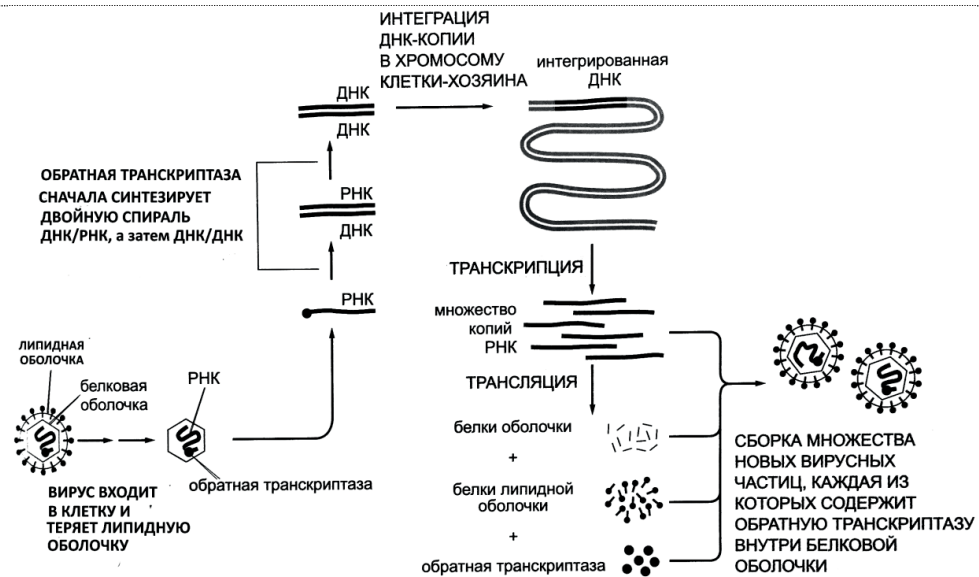
How is the genetic information embedded in the RNA genome realized? Thanks to the study of the life cycle of retroviruses in 1970, it became clear that the central dogma requires a significant addition. Two American virologists, David Baltimore and Howard Martin Temin, discovered the real mechanism of information transfer from viral RNA to DNA, i.e., exactly the opposite of what takes place in the cells of higher organisms. This process was called reverse transcription, and the enzyme that carries it out was called reverse transcriptase or replicase. Both discoverers of reverse transcriptase received the Nobel Prize in Physiology or Medicine in 1975.

Today, the central dogma of molecular biology in its final form is depicted as follows:



This means that viral RNA is the source of genetic information and at the same time mRNA. Therefore, in the affected host cell, viral proteins begin to be synthesized on the ribosomes instead of its own. After this, the process of self-assembly of these proteins with nucleic acid and the formation of new viral particles occurs. The host cell is depleted and dies or begins to divide intensively, forming malignant tumors.

Diagram of retrovirus reproduction:



Stages of retrovirus reproduction:

- ✓ After the retrovirus enters the cell, its RNA is transcribed into double-stranded DNA using a specific viral enzyme – reverse transcriptase, capable of synthesizing DNA on an RNA template (viral RNA).
- ✓ After completion of synthesis, the viral double-stranded DNA is transported into the cell nucleus and integrated into the structure of chromosomal DNA, where it can permanently reside in any chromosome, forming a so-called provirus.
- ✓ In some cases, proviral DNA is immediately transcribed into RNA, but sometimes the provirus is in a "dormant" state for a long time, after which it is activated with the formation of daughter viral particles. When transcribing proviral DNA, the genetic information of the retrovirus is transmitted using cellular enzymes in the usual, forward direction.
- ✓ From the formed viral RNAs and proteins, new viral particles are assembled, which leave the cell, spread and infect other cells.

Task 2.5 Draw a diagram of the structure of a bacteriophage.

The diagram should indicate:

- 1 – NA;
- 2 – protein coat;
- 3 – internal core;
- 4 – sheath;
- 5 – fibrils.

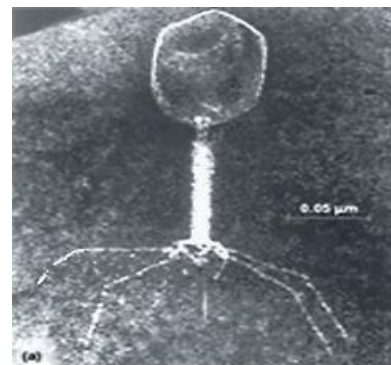
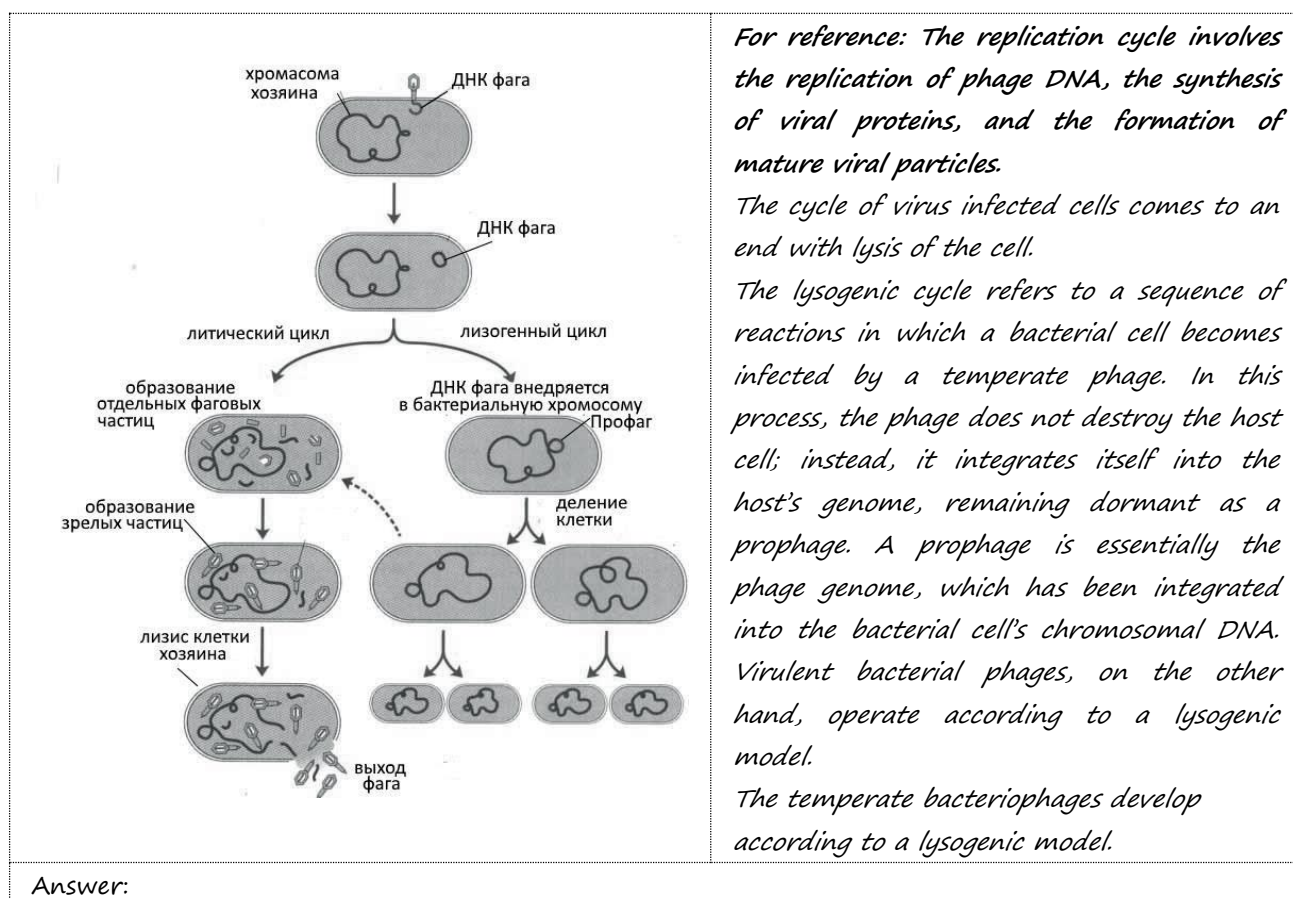


Fig.1 Figure-diagram of the bacteriophage structure

Work 2.6 Using the handout material, describe the mechanism of penetration and reproduction of a bacteriophage in a bacterial cell



Examine the micrographs below. What process is shown in photo 1 and photo 2?

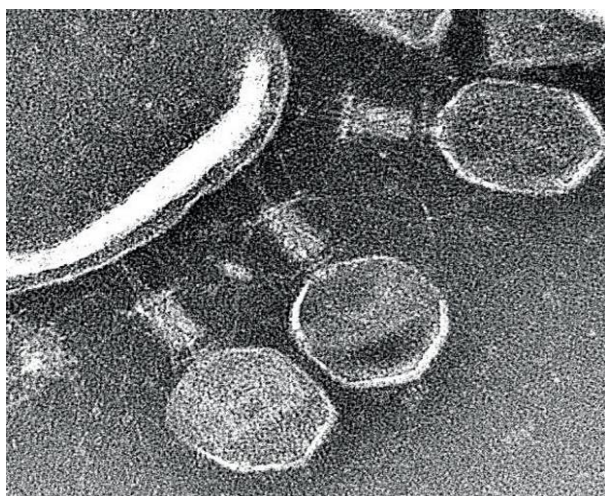


Photo 1.

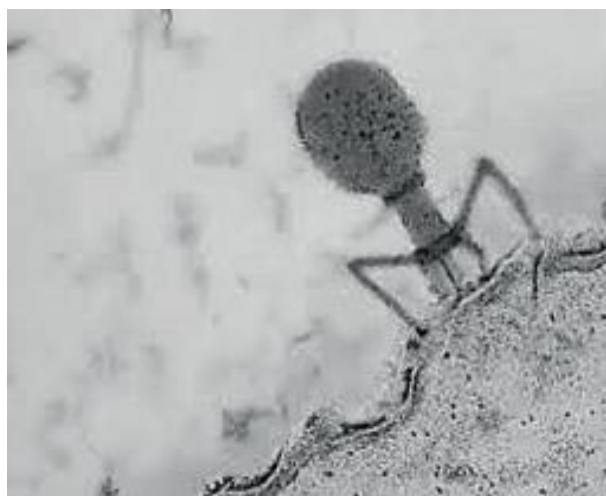
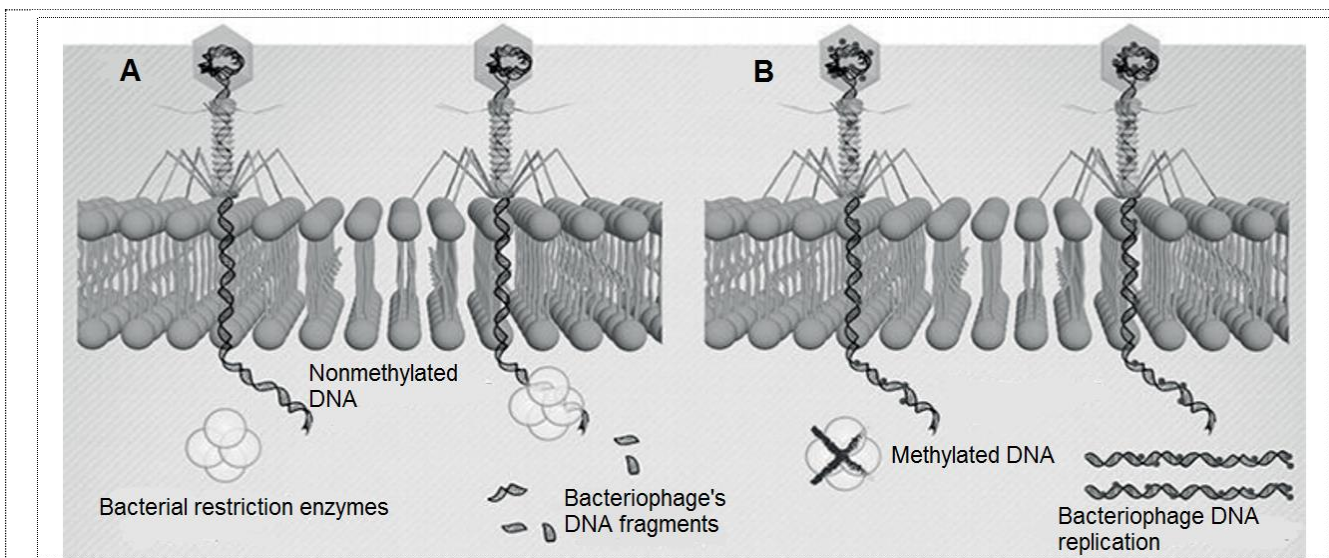


Photo 2.

Work 2.7 According to experts, every two days, bacteriophages destroy half of the world's population of bacteria. Despite such a highly effective antibacterial action of phages, bacteria have not disappeared from the face of the planet.

Task: Using the diagram below, draw your own conclusions and explain this fact.



INDEPENDENT STUDENT WORK:

1. An experimenter infected bacteria with a bacteriophage.

- A) He infected the first group of bacteria with bacteriophages containing radioactive sulfur
- B) the second - with bacteriophages containing radioactive phosphorus,
- C) the third - with bacteriophages containing radioactive carbon.

How will the content of the radioactive element inside the bacteria change after infection with a bacteriophage? For each group of bacteria, determine the corresponding nature of the change:

(1) will increase, (2) will decrease, (3) will not change. Numbers in the answer can be repeated.

ANSWER: ____

2. Establish the correct sequence of reproduction stages of DNA-containing viruses. Write the corresponding sequence of numbers in the table.

- 1) release of the virus into the environment
- 2) synthesis of viral protein in the cell
- 3) insertion of DNA into the cell
- 4) synthesis of viral DNA in the cell
- 5) attachment of the virus to the cell

ANSWER: ____

3. Establish the sequence of stages of penetration and parasitism of viral particles in the cell. Write down the corresponding sequence of numbers in your answer.

- 1) attachment of the virus by its appendages to the cell envelope
- 2) penetration of viral DNA into the cell
- 3) dissolution of the cell envelope at the site of virus attachment
- 4) synthesis of viral DNA and proteins
- 5) release of viral particles from the host cell
- 6) formation of new virions

ANSWER: ____

4. Establish the sequence of processes occurring during infection of a human with human immunodeficiency virus (HIV). Write down the corresponding sequence of numbers.

- 1) release of RNA from the capsid
- 2) translation of viral proteins
- 3) penetration of the virus into leukocytes
- 4) integration of DNA into the leukocyte chromosome
- 5) reverse transcription

ANSWER: ____

5. Establish the sequence of stages of development of the RNA-containing human immunodeficiency virus (HIV) from the moment it enters a lymphocyte. Write down the corresponding sequence of numbers.

- 1) synthesis of viral DNA on viral RNA (reverse transcription)
- 2) penetration of viral RNA into the lymphocyte cytoplasm
- 3) synthesis of mRNA and viral proteins in the lymphocyte
- 4) self-assembly of viral particles
- 5) integration of viral DNA into the lymphocyte chromosome

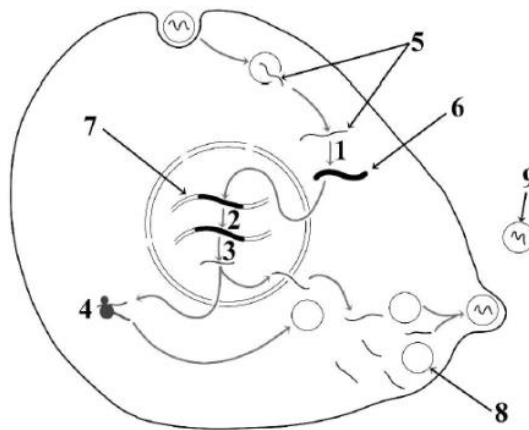
ANSWER: ____

6. Establish the sequence of stages of retrovirus protein synthesis. Write down the corresponding sequence of numbers in the table.

- 1) integration of viral DNA into the host chromosome
- 2) penetration of the viral genome into the cell
- 3) binding of viral mRNA with host ribosomes
- 4) DNA synthesis on an RNA template
- 5) elongation of the polypeptide chain

ANSWER: ____

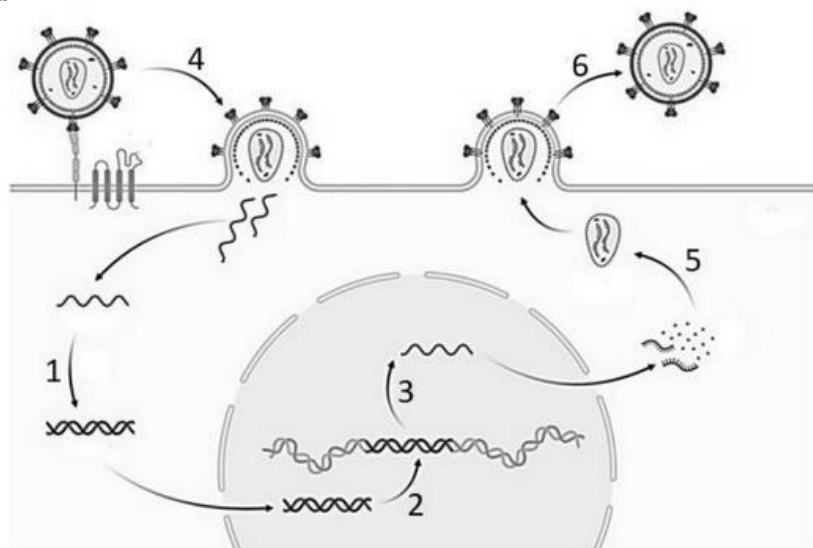
7. Examine the diagram of the retrovirus life cycle. Establish a correspondence between the processes and their characteristics, indicated by numbers 1, 2, 3, 4 on the diagram. Write numbers 1-4 in the order corresponding to the letters.



- A) RNA molecule serves as a template for DNA synthesis
- B) main enzyme of the process – RNA polymerase
- C) duplication of DNA molecule
- D) peptide bonds are formed
- E) reverse transcriptase enzyme is involved
- F) formation of RNA molecule on a DNA template

ANSWER: ____

8. Establish a correspondence between characteristics and processes, indicated in the figure by numbers 1, 2, 3. Write down these numbers in the order corresponding to the letters.

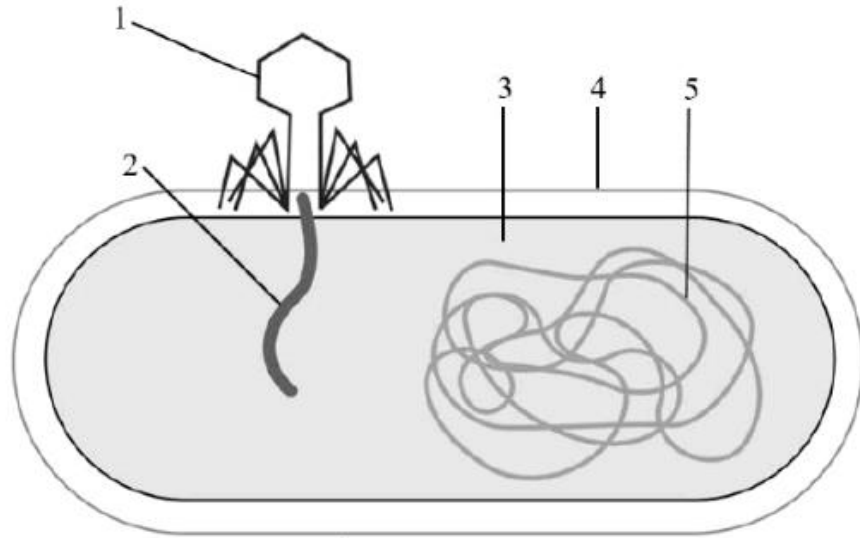


- A) DNA synthesis on an RNA template

- B) can lead to a mutation in humans
- C) reverse transcription
- D) insertion of the viral genome into the host genome
- E) viral RNA synthesis
- F) carried out by DNA-dependent RNA polymerase

ANSWER: ____

9. Establish a correspondence between characteristics and structures, indicated by numbers 1, 2, 3 in the figure. Write these numbers in the order corresponding to the letters.



- A) contains different types of RNA
- B) is a viral genome
- C) protein capsid of a bacteriophage
- D) carries out translation of viral proteins
- E) ensures penetration of DNA into the host cell
- F) contains genes of the phage capsid

ANSWER: ____

10. Viruses are pathogens of diseases in humans, domestic animals, and cultivated plants. Nevertheless, viruses can be beneficial, being used in medicine, agriculture, biotechnology, scientific research, etc. Give at least three examples of using viruses for human benefit.

ANSWER:

11. Currently, there is a quite large number of antiviral drugs on the pharmaceutical market. Explain the principle of their action.

ANSWER:

12. Indicate the specifics of self-reproduction of RNA-containing viruses.

ANSWER:

[illegible]

13. Explain why some groups of viruses, and consequently their DNA, can persist in the host cell for a long time and be transmitted to daughter cells during division? Name this group of viruses.

ANSWER:

[illegible]

14. Specify the classes of biopolymers and their monomers included in the viral particle (simple and complex). What structures of the virus will be formed by them? How will they differ from the composition of any body cell?

ANSWER:

[illegible]

15. Explain how the envelope of complex viruses is formed. Indicate the main biopolymers of this envelope. Give examples of complex viruses.

ANSWER:

16. Name and describe the first stage of interaction between the virion of a virus and a host cell? What explains the strict determination of the pathways of viral entry.

ANSWER:

17. A strict determination of the pathways of virus penetration (specificity) into the cell has been established. Explain this fact using the influenza virus as an example?

ANSWER:

18. Indicate the main mechanisms of action of antiviral drugs.

ANSWER:

Grade for class _____

Teacher's signature _____

Date _____

Date: _____

TOPIC 3: PROKARYOTIC CELL

INDEPENDENT STUDENT WORK: PREPARATION FOR THE CLASS

1. Establish a correspondence between the features of organisms and representatives: 1) Immunodeficiency virus, 2) E. coli. Write numbers 1 and 2 in the correct order.

- A) No cell wall
- B) Hereditary material is enclosed in circular DNA
- C) Hereditary material is enclosed in RNA
- D) May have a flagellum
- E) Intracellular parasite
- F) Human symbiont

ANSWER: _____

2. Establish a correspondence between the features of a biological object and the object to which this feature relates: 1) bacteriophage, 2) E. coli. Write numbers 1 and 2 in the correct order.

- A) consists of nucleic acid and capsid
- B) cell wall made of murein
- C) outside the organism is in the form of crystals
- D) can be in symbiosis with humans
- E) has ribosomes
- F) has a tail canal

ANSWER: _____

3. Establish a correspondence between the trait of an organism and the group for which it is characteristic: 1) prokaryotes, 2) viruses.

- A) cellular body structure
- B) presence of own metabolism
- C) insertion of own DNA into host cell DNA
- D) consists of nucleic acid and protein coat
- E) reproduction by binary fission
- F) ability for reverse transcription

ANSWER: _____

4. Establish a correspondence between characteristics and natural objects: 1) viruses, 2) bacteria. Write numbers 1 and 2 in the order corresponding to the letters.

- A) strictly parasitic lifestyle
- B) ability to synthesize protein molecules
- C) formation of spores to endure unfavorable environmental conditions
- D) lack of own metabolism
- E) presence of a cell wall
- F) division of the cell in two

ANSWER: _____

5. Establish a correspondence between the features of structure and vital activity 1) human immunodeficiency virus and 2) staphylococcus. Write numbers 1 and 2 in the order corresponding to the letters.

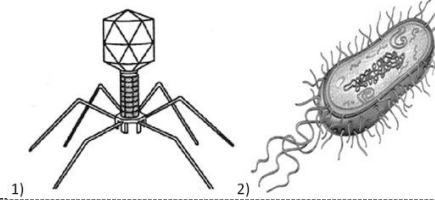
- A) genome is represented by an RNA molecule
- B) capable of reverse transcription
- C) represented by parasitic and free-living strains
- D) has additional genes in plasmids

E) parasitizes in lymphocytes

F) dies under the action of antibiotics

ANSWER: ____

6. Establish a correspondence between functions and the organisms for which they are characteristic. Write numbers 1 and 2 in the correct order.



A) has an envelope made of murein

B) is an obligate cellular parasite

C) capable of spore formation

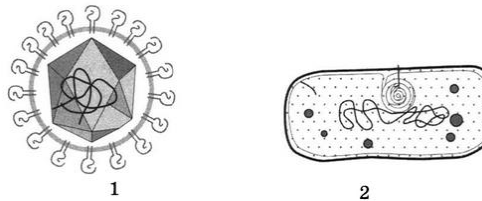
D) reproduces by binary fission

E) consists of DNA or RNA and a capsid

F) capable of crystallization

ANSWER: ____

7. Establish a correspondence between characteristics and life forms shown in the figure. Write numbers 1 and 2 in the order corresponding to the letters.



A) forms spores under adverse effects

B) is an obligate intracellular parasite

C) has a nucleoid

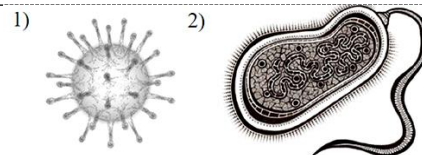
D) the membrane forms outgrowths to accommodate enzymes

E) the genetic apparatus is represented by DNA or RNA molecules

F) has a protein-lipid membrane and a capsid

ANSWER: ____

8. Establish a correspondence between characteristics and life forms shown in the figures. Write numbers 1 and 2 in the order corresponding to the letters.



A) has no own metabolism

B) maintains its own homeostasis

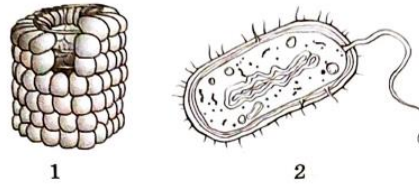
C) can be autotrophic and heterotrophic

D) contains DNA or RNA as a carrier of hereditary information

E) reproduces only inside host cells / F) can move independently

ANSWER: ____

9. Establish a correspondence between characteristics and life forms shown in figures 1 and 2. Write numbers 1 and 2 in the order corresponding to the letters.



- A) is a non-cellular life form
- B) has a nucleoid and ribosomes
- C) reproduces only in living cells
- D) reproduces by division
- E) has no own metabolism
- F) survives adverse conditions in a state of spore

ANSWER: ____

10. Find three errors in the given text. Indicate the numbers of the sentences in which they are made.

(1) In prokaryotic cells there is no formed nucleus. (2) Bacteria, as representatives of pre-nuclear organisms, have a nucleoid. (3) Metabolism and energy transformation are characteristic of bacteria, as for all living things. (4) All bacteria are characterized by an anaerobic type of metabolism. (5) By type of nutrition, they are divided into autotrophs and heterotrophs. (6) All autotrophic bacteria synthesize organic substances from inorganic ones using light energy. (7) Photosynthesis in autotrophic bacteria occurs in chloroplasts, as in plants.

ANSWER: ____

Task 3.1 Examine Figure 1. Familiarize yourself with the features of the internal structure of prokaryotes

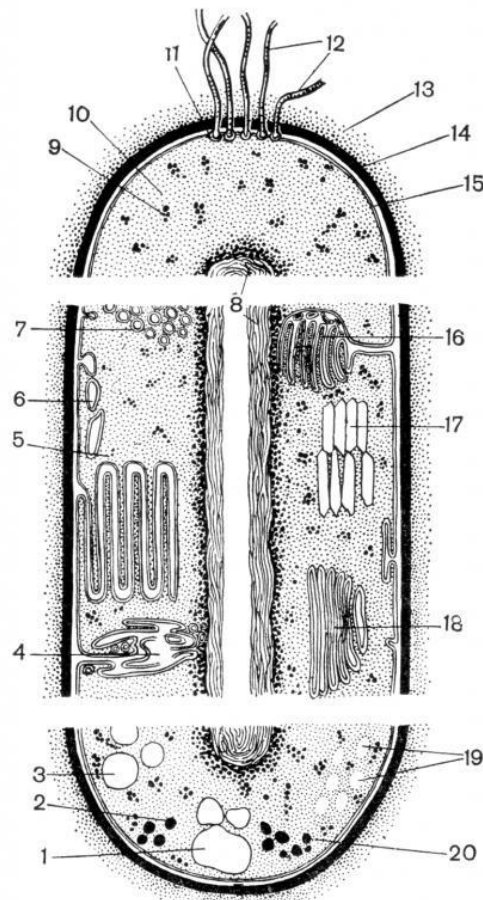


Fig. 1 Schematic representation of the structure of a bacterial cell (according to H. Schlegel):

1 - granules of poly- β -hydroxybutyric acid; 2 - fat droplets; 3 - sulfur inclusions; 4 - tubular thylakoids; 5 - lamellar thylakoids; 6 - vesicles; 7 - chromatophores; 8 - nucleus (nucleoid); 9 - ribosomes; 10 - cytoplasm; 11 - basal body; 12 - flagella; 13 - capsule; 14 - cell wall; 15 - cytoplasmic membrane; 16 - mesosome; 17 - gas vacuoles; 18 - lamellar structures; 19 - polysaccharide granules; 20 - polyphosphate granules.

The main structures of a bacterial cell are presented in the upper part of the figure, additional membrane structures present in phototrophic and non-phototrophic bacteria - in the middle part, and inclusions of reserve substances - in the lower part.

Task 3.2. Examine Figure 2. Familiarize yourself with the morphological features of prokaryotes

Indicate what principle is the basis for the morphological classification of prokaryotes

Indicate the physiological properties of prokaryotes

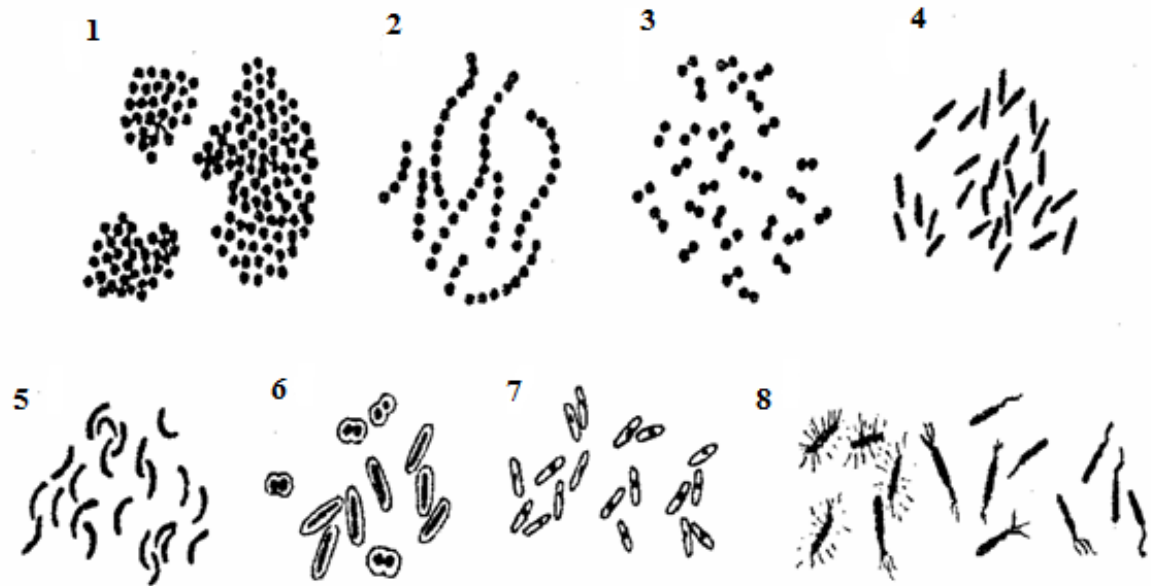


Fig. 2 Morphological forms of bacteria:

1 - staphylococci; 2 - streptococci; 3 - diplococci; 4 - bacilli;
5 - spirilla; 6 - capsular bacilli and cocci; 7 - flagellated bacilli

Task 3.3 Describe the structure of a prokaryotic cell and indicate the functions of all structures.

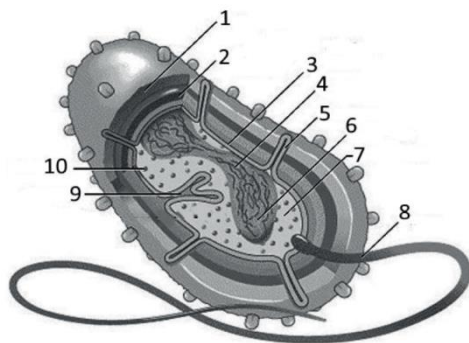


Fig.3

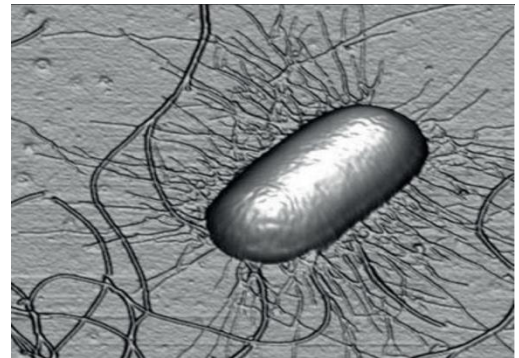


Fig.4

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.

Task 3.4 Give examples of diseases caused by bacteria

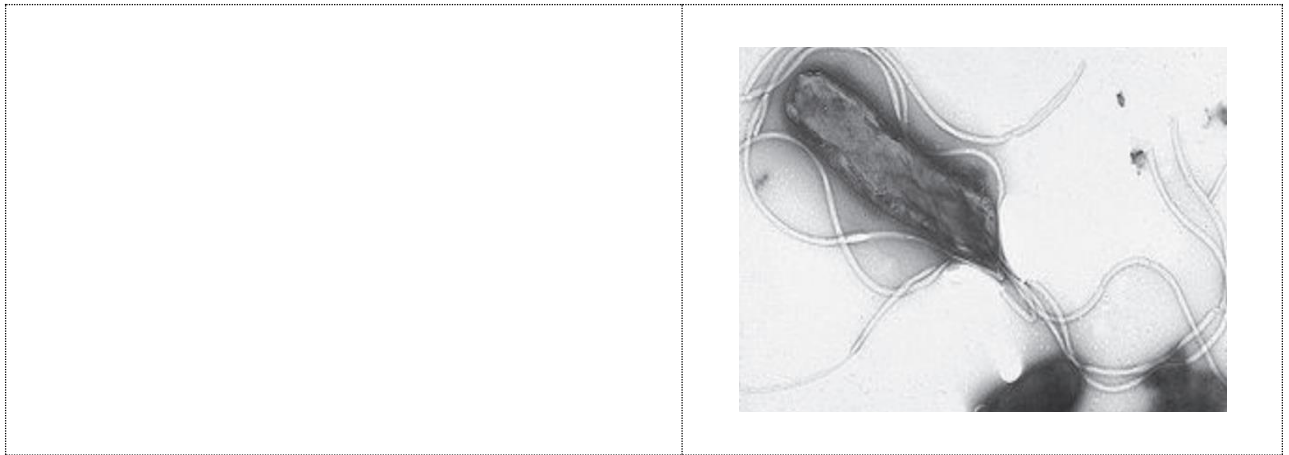
CLASSROOM WORK:

Task 3.5 Situational task:

A young woman applied to the local doctor in the outpatient clinic with complaints of stomach pain and frequent heartburn. She associates her malaise with the recently diagnosed helicobacteriosis in older family members. Endoscopic examination revealed erosive gastritis. Analysis of a biopsy from the gastric mucosa and duodenum confirmed the diagnosis of helicobacteriosis.

*Task: using the diagram and handout material, draw the causative agent of helicobacteriosis – *Helicobacter pylori* in your workbook. The diagram should indicate:*

1) envelope, 2) cytoplasm, 3) nucleoid, 4) flagellum



How do you think the woman could have been infected? What preventive measures are needed to prevent helicobacteriosis?

Your answer: _____

For reference: *Helicobacter pylori* bacteria are currently the most common. More than half of the world's population can be considered carriers of this bacterium.

The bacterium lives in the gastrointestinal tract (in the pyloric part of the stomach, from which it got its name). It is well adapted to the aggressive acidic environment of the stomach. The exact mechanism of infection is still unknown. There is only an assumption that infection can occur – through dirty hands and contaminated food or water. The disease can be considered familial. If one family member gets infected with the bacterium, the symptoms of the disease will appear in all other family members. Symptoms of the disease: stool problems (either constipation or diarrhea, heartburn, causeless nausea or vomiting, bad breath). The disease leads to stomach and duodenal ulcers, gastritis, and a predisposition to stomach cancer is noted.

Task 3.6 Microscopic examination of dental plaque

Dental plaque is an accumulation of bacteria in the form of a film that forms on the teeth (including in a healthy person). Dental plaque includes both aerobic and facultatively anaerobic bacteria and begins to form as early as 1–2 hours after brushing the teeth.

Bacteria of dental plaque release acid, but in the first hours it is neutralized by saliva. But after a few hours, the plaque becomes thick and dense, saliva stops penetrating it, and the acid begins to dissolve the tooth enamel, which eventually leads to the development of caries. Caries is an infectious disease caused by the bacteria *Streptococcus Mutans et Salivarius*, in which a process of demineralization and softening of tooth tissues occurs, subsequently leading to the formation of a defect in the form of a cavity.

PROCEDURE

1. A drop of water is applied to a glass slide, then a match is used to take some dental plaque near the gums and mixed with the drop of water. Then a fixed preparation is made, covered with a coverslip and examined first under medium magnification, then under high.
2. We determine the various forms of bacteria. In the preparation, various forms of bacteria are visible: *Streptococcus albus*, *Bac. maximus buccalis* and others, sometimes random species. There are about 160 types of microorganisms in the oral cavity – this is one of the most seeded parts of the human body.

Bac. maximus buccalis – aerobe, has the shape of long, quite thick threads. It produces yellow, pale yellow, or golden colonies.

Spirochaeta buccalis – aerobe, cells look like long, quite large spirally coiled threads.

Spirochaeta dentium – also a spirally coiled thread, but thinner than *S. buccalis*.

Vibrio buccalis – small crescent-shaped cells, monotrichous, like all previous species – a representative of the normal microflora of the oral cavity.

Draw the preparation and sign it

Fig. Bacteria of dental plaque

Tasks:

1. An average of up to 50 yeast cells per unit area of water was found under a microscope. After 4 hours, the culture was diluted 10 times and a new preparation was prepared for microscopy. What was the average time between cell divisions if an average of 80 cells per unit area was observed under the microscope?

2. Calculate how many days bacteria can remain viable in the form of spores, if it is known that cholera spores withstand unfavorable conditions for 2 days; plague 4 times, typhoid 30 times, tuberculosis 150, anthrax 1826 times longer than cholera.

3. Dysentery is a bacterial disease ("disease of dirty hands") of an epidemic nature. From the hands of patients with acute or chronic forms of dysentery, bacteria get into food, water, etc., and remain viable for a long time. In the external environment, on dishes, vegetables, fruits, banknotes, in sea and river water, bacteria live up to 1 month. Thus, on berries (blueberries, raspberries) 2 days, on lettuce 3 times longer, on cucumbers 3 times longer than on lettuce. How many days are bacteria a source of infection on lettuce and cucumber fruits?

4. As the distance from the earth's surface increases, the air becomes cleaner and cleaner, even over large settlements. According to the research of E. N.

Mishustin, at an altitude of 2000 m on average – 500 bacteria in 1 m of air, and at an altitude of 500 m – 40-60 times more. How many bacteria are in 1 m³ of air at an altitude of 500 m above the earth's surface in the city?

Grade for the class _____

Teacher's signature _____

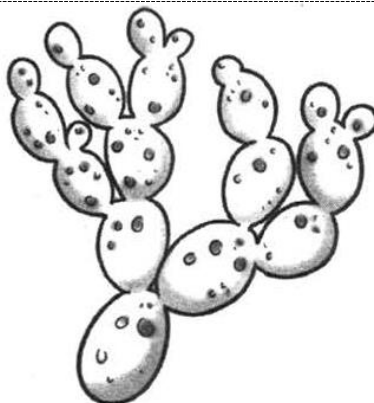
Date _____

Date: _____

TOPIC 4: FUNGI

INDEPENDENT STUDENT WORK: PREPARATION FOR THE CLASS

1. Choose three correct answers out of six and write down the numbers under which they are indicated. What features are characteristic of the organism shown in the figure?



1) reproduction method - budding

2) chemotrophic nutrition

3) unicellular fungus

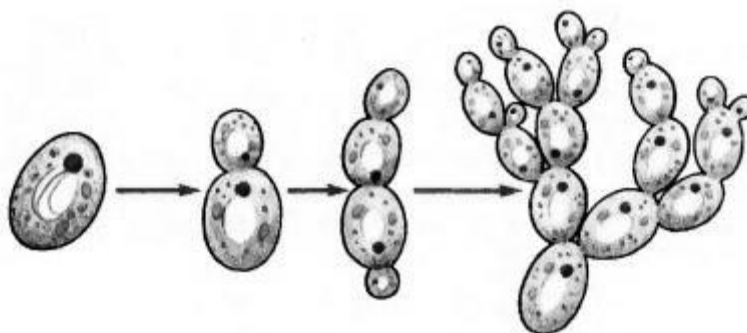
4) used in baking

5) forms mycorrhiza

6) multicellular mycelium

ANSWER: ____

2. Choose three correct answers out of six and write down the numbers under which they are indicated. What features are characteristic of the specified organism?



- 1) multicellular mycelium
- 2) heterotrophic nutrition
- 3) green plastids
- 4) budding
- 5) reserve nutrient - glycogen
- 6) root-like formations - rhizoids

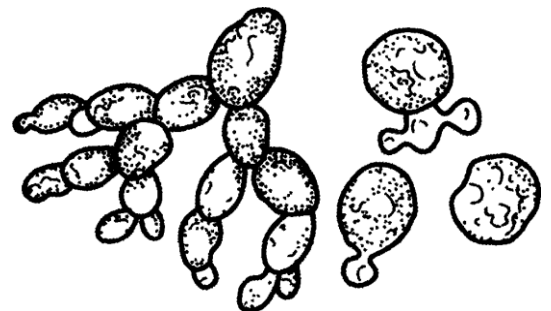
ANSWER: ____

3. Choose three correct answers out of six and write down the numbers under which they are indicated. Which of the following features can be used to describe a fungal cell?

- 1) autotrophic nutrition
- 2) cell wall contains chitin
- 3) large central vacuole
- 4) reserve carbohydrate — glycogen
- 5) direct cell division in two
- 6) metabolic product — urea

ANSWER: ____

4. Choose three correct answers out of six and write the numbers under which they are indicated in the table. Which of the following features can be used to describe the method of division shown in the figure of the organism?



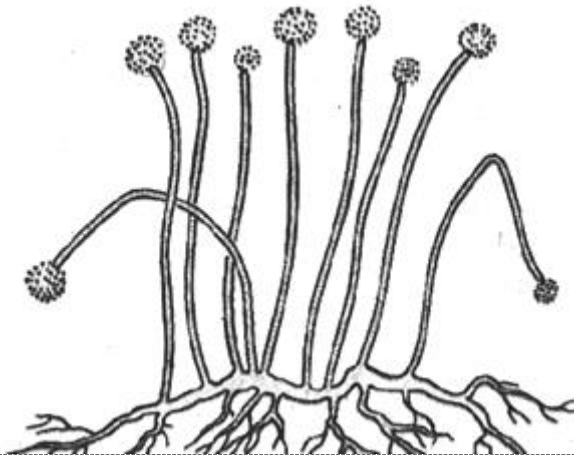
- 1) consists in the breakdown of the body of a multicellular organism into two or more parts, which then turn into independent individuals
- 2) the simplest form of asexual reproduction
- 3) peculiar to both unicellular and multicellular organisms
- 4) characteristic of coelenterates
- 5) a small outgrowth (bud) appears on the body of the mother individual, and then separation (budding off) of the daughter individual occurs

6) the original mother cell divides into two daughter cells

ANSWER _____

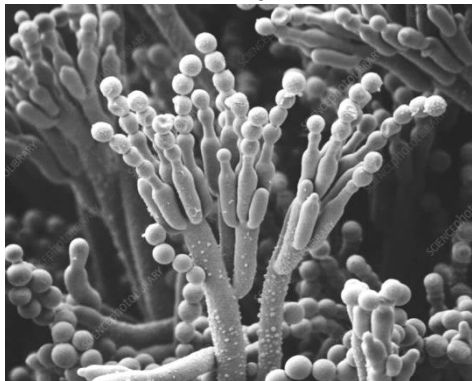
5. Choose three correct answers out of six and write down the numbers under which they are indicated. What features are characteristic of the organism shown in the figure.

- 1) saprotrophic nutrition
- 2) multicellularity
- 3) unicellularity
- 4) reproduction by budding
- 5) presence of a cell wall made of chitin
- 6) feeding on dissolved mineral substances



ANSWER: ____

6. Choose three correct answers out of six and write down the numbers under which they are indicated. What features are characteristic of the kingdom to which the organism shown in the figure belongs.



- 1) presence of tissues
- 2) storage of glycogen
- 3) mycelium forms hyphae
- 4) final excretory product – urea
- 5) formation of gametes
- 6) have generative organs

ANSWER: ____

7. Establish a correspondence between the characteristic and the fungus to which it relates: 1) tinder fungi, 2)

ergot, 3) penicillium, 4) yeast. Write numbers 1-4 in the order corresponding to the letters.

- A) reproduction by budding
- B) infects grain crops
- C) sporangia in the form of a brush
- D) destroys wood
- E) forms black horns containing poisonous substances
- F) is used to produce antibiotics

ANSWER: ____

8. Establish a correspondence between the characteristic and the fungus to which it relates:

1) yeast, 2) aspen mushroom, 3) penicillium. Write numbers 1-3 in the order corresponding to the letters.

- A) have sporangia in the form of a brush
- B) are used to produce antibiotics
- C) form mycorrhiza
- D) reproduce by budding
- E) are used in the production of cheeses
- F) during alcoholic fermentation form ethanol

ANSWER: ____

9. Establish a correspondence between features and groups of fungi for which they are characteristic: 1) cap fungi, 2) molds. Write numbers 1 and 2 in the order corresponding to the letters.

- A) have sporangia in the form of a head or a brush
- B) are used in the production of cheeses
- C) form mycorrhiza
- D) tubular and lamellar fungi are distinguished
- E) are used in biotechnology to produce antibiotics
- F) have a fruiting body

ANSWER: ____

10. It is known that Mucor is an aerobic, unicellular organism, a representative of the Fungi kingdom. Choose from the text below three statements relating to the description of the above features of Mucor. (1) Mucor has the features of plants, animals, and has its own specific features, its body is represented by mycelium. (2) Its mycelium is a branched multinucleated cell. (3) Germinating in bread, Mucor makes it inedible. (4) The final processes of energy metabolism are carried out in mitochondria. (5) Substances that kill bacteria are formed in the Mucor cell.

ANSWER: ____

CLASSROOM WORK:

Laboratory work. 4.-1. Microscopic examination of baker's or brewer's yeast.

Yeasts in cultures on solid nutrient media grow in the form of colonies of different colors, shapes and consistencies, and in liquid media they form turbidity, films and precipitates. At first glance, yeast colonies differ little from bacterial ones: they are not covered with aerial mycelium like actinomycetes and fungi, and most often they are smooth, thick and dense, or less often – mucous, spreading. In color, they can be pure white, brownish-beige, brown (during spore formation) or bright, painted in all tones of yellow-orange-red color.

The yeast thallus in its simplest form is a single cell. This cell has all the main structures characteristic of fungi. Sometimes cells can combine into various more or less strong structures in the form of pseudomycelium or true mycelium. The shape of a yeast cell largely depends on the method of vegetative reproduction. It can occur by budding, division, and budding division. During budding, round, ovoid or oval cells arise. Examine the yeast in a crushed drop under an immersion objective. Draw a few cells.

Fig.1 Structure of baker's yeast

Tasks:

1. In the experiment, the subject investigated some characteristics of the medium during the passage through a bacterial filter of a sweetened water solution, to which yeast had been added a few hours before the experiment.

How will the alcohol saturation and the amount of yeast change in the solution? When answering, assume that the experiment was carried out instantly: do not take into account the time of passage through the filter.

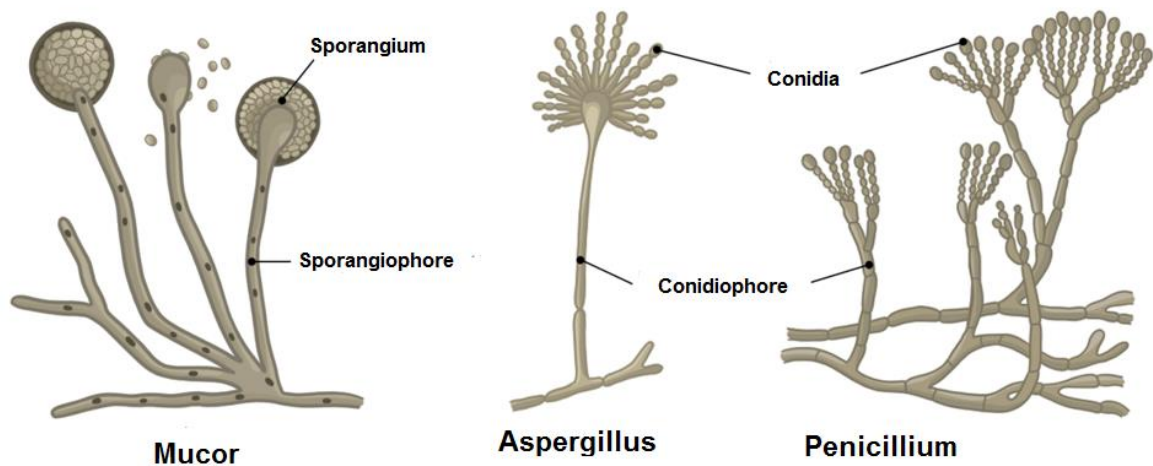
For each value, determine the corresponding nature of its change:

- 1) will not change
- 2) will decrease
- 3) will increase

Alcohol saturation:

Amount of yeast:

Zygomycetes



This class includes lower fungi with well-developed non-cellular or, in the mature state, cellularly divided mycelium. Asexual reproduction is carried out by motionless, flagella-less sporangiospores or conidia. The sexual process is zygotamous. Saprotrophs or parasites.

The most common saprotrophic strains:

Mucor (*Mucor*). An extensive genus of molds; the mycelium is white, develops in the substrate and forms aerial unbranched sporangiophores with spherical sporangia. The sporangium is separated from the sporangiophore by a septum concave towards the sporangium (columella); spores are dark-colored.

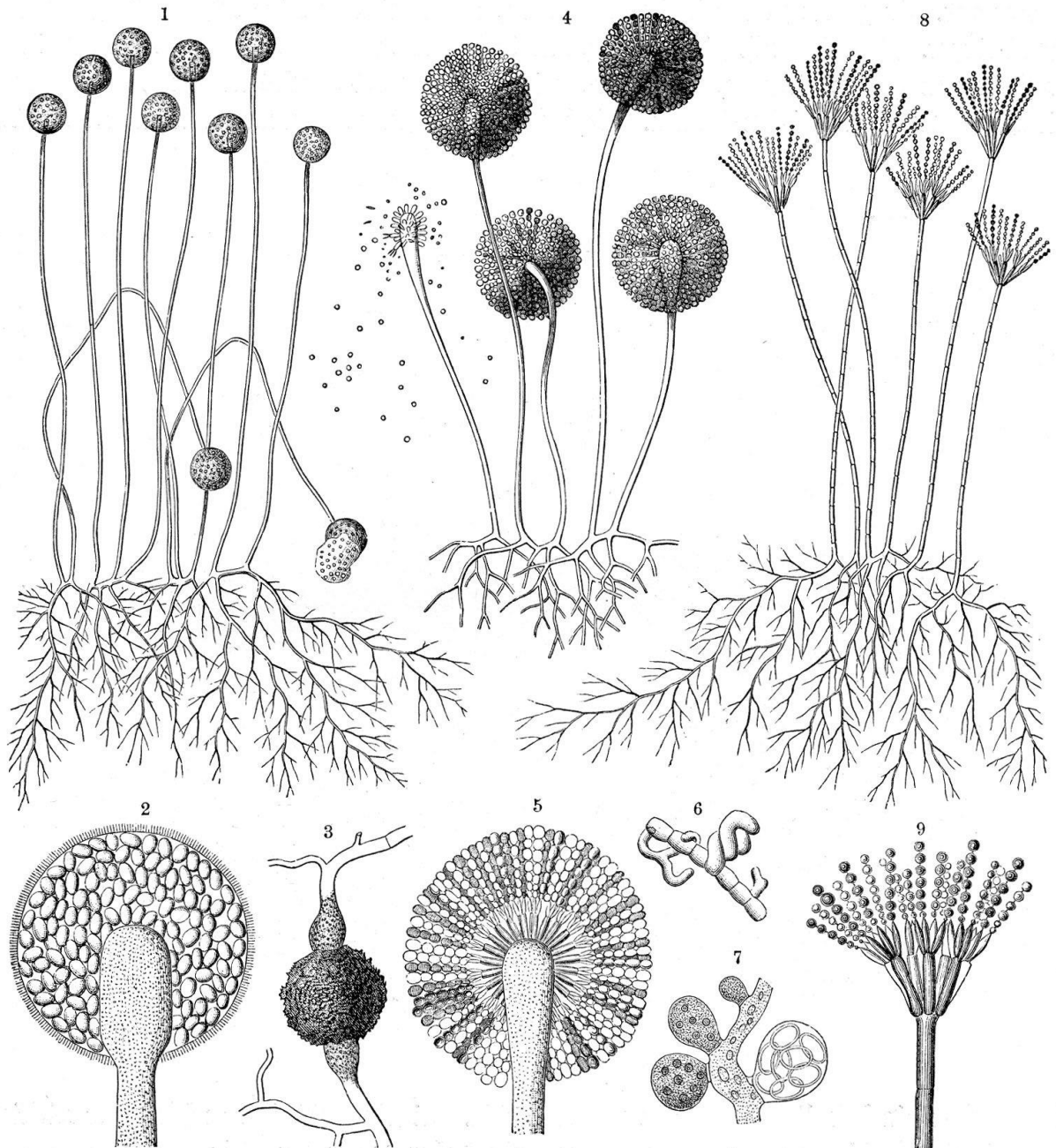
Rhizopus (*Rhizopus*). Species of this genus live in decaying plant mass; cause rotting of fruits and vegetables during their storage, sporangiophores, unlike those of *Mucor*, are arranged in bunches on special branches of the mycelium; spores are black.

Pilobolus (*Pilobolus*). Mycelium develops on manure, short sporangiophores of a peculiar shape, with swellings at the base and under the sporangium, sporangia are black, when ripe they are forcefully thrown off (shoot).

The genus *Mucor* (*Mucor*) includes more than 150 species of saprotrophic fungi living in the soil, on various plant residues, on food products, leather, books and similar substrates and forming white molds.

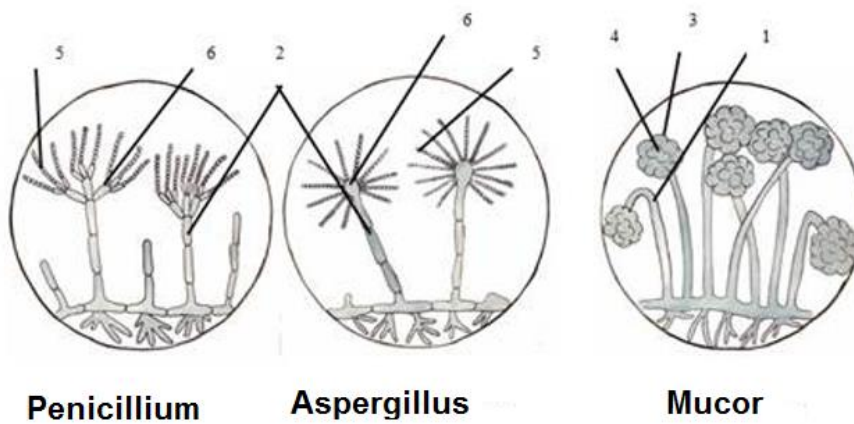
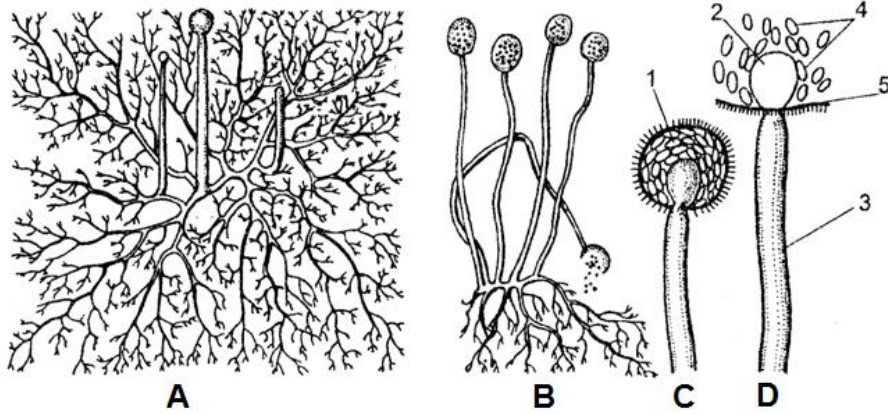
One of the common species is *M. mucedo*, often called white pin mold.

To obtain a culture of *Mucor*, you need to take a piece of bread, soak it in warm water, and then put it on a plate with damp filter paper, under which there is a thin layer of moistened cotton wool. Having kept the piece of bread open for 2-3 minutes (so that fungal spores get onto its surface from the air), cover the prepared culture with a jar and put it in a dark place. The optimum temperature is 25-27°C.



Schimmel: 1 Mucor Mucedo, 40fach vergrößert, 2 Längsschnitt durch ein Sporangium von Mucor Mucedo, 260fach vergrößert, 3 Fruchtbildung von Mucor Mucedo, 180fach vergrößert; 4 Aspergillus niger, 30fach vergrößert, 5 Längsschnitt durch einen Sporenträger des Aspergillus niger; 6 Befruchtung des Penicillium crustaceum (nach Brefeld); 7 Sporangienbildung des Aspergillus (nach Eidam); 8 Penicillium crustaceum, 40fach vergrößert, 9 ein Sporenträger des Penicillium crustaceum, 200fach vergrößert. (Zu S. 396.)

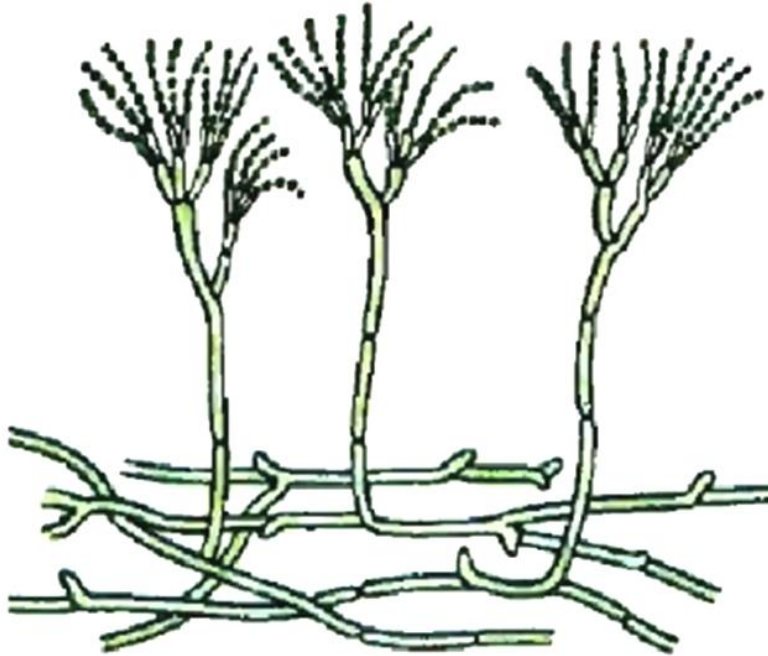
2. Label the structures indicated in the figure. Indicate their functions.



A -	1.
B -	2.
C -	3.
D -	4.
1.	5.
	6.

2.	
3.	
4.	
5.	

3. Name the organism shown in the figure and the kingdom to which it belongs. What is the role of these organisms in the ecosystem? For what purpose is this organism used by humans? Name at least three points.



4. Indicate the main features of organisms belonging to the Fungi kingdom. Which of the features bring them closer to the representatives of the Plant kingdom, and which - to the representatives of the Animal kingdom?

5. For what purpose are yeast fungi used when baking bread and bakery products? What process occurs in this case?

6. What are antibiotics, from what were they first obtained, and where are they used?

Grade for the class _____

Teacher's signature _____

Date _____

Date: _____

TOPIC 6: CHEMICAL COMPOSITION OF THE CELL

INDEPENDENT STUDENT WORK

Task 6.1 Give definitions for concepts and terms:

Covalent bond -	
Ionic bond -	
Hydrogen bond -	
Van der Waals force -	
Hydrophobic interactions -	

1. Choose one or several correct answers.

All the features listed below, except two, can be used to describe a protein molecule. Identify the two features that "drop out" of the general list, and write the numbers under which they are indicated in the table

- 1) has peptide bonds
- 2) consists of nucleotides
- 3) is part of a ribosome

4) capable of replication

5) can be an enzyme

ANSWER _____

2. Establish a correspondence between characteristics and substances: for each item given in the first column, select the corresponding item from the second column.

CHARACTERISTICS	SUBSTANCES
A) are biological catalysts	1) proteins 2) carbohydrates
B) contain peptide bonds	
C) are synthesized on ribosomes	
D) are divided into monosaccharides, disaccharides, and polysaccharides	
E) are the main source of energy	

Write the selected numbers in the table under the corresponding letters:

A	B	C	Г	E	

ANSWER _____

3. Establish a correspondence between features and types of molecules: for each item given in the first column, select the corresponding item from the second column.

FEATURES	TYPES OF MOLECULES
A) has the ability to replicate	

B) can form a branched structure	1) DNA 2) Polysaccharide
C) consists of nucleotides	
D) is formed by joining molecules of simple carbohydrates	
E) performs protective and energy functions	
F) provides template synthesis of ribonucleic acids	

Write the selected numbers in the table under the corresponding letters:

A	B	C	Г	E	F

ANSWER _____

4. Establish a correspondence between characteristics and chemical elements: for each item given in the first column, select the corresponding item from the second column.

CHARACTERISTICS	CHEM. ELEMENTS
A) participates in the conduction of nerve impulses	1) phosphorus 2) potassium 3) iron
B) participates in oxygen transport	
C) is a part of nucleic acids	
D) is a part of bone tissue	
E) is a part of the lipid layer	

Write the selected numbers in the table under the corresponding letters:

A	B	C	Г	E	F

ANSWER _____

5. Establish the correspondence and enter the answer.

Analyze the table "Organic substances of the cell". Fill in the empty cells of the table using the terms and concepts given in the list. For each cell marked with a letter, select the corresponding term or concept from the proposed list.

SUBSTANCES	MONOMER	MAIN FUNCTION(S)
_____ A	Amino acid	Enzymatic, regulatory, structural
Nucleic acids	_____ B	Storage and transmission hereditary information
Carbohydrates	Glucose	_____ C

List of terms and concepts:

- 1) proteins
- 2) lipid
- 3) glycerol
- 4) fatty acids
- 5) nucleotide
- 6) storage and enzymatic
- 7) transport and protective
- 8) energy

Write the selected numbers in the table under the corresponding letters:

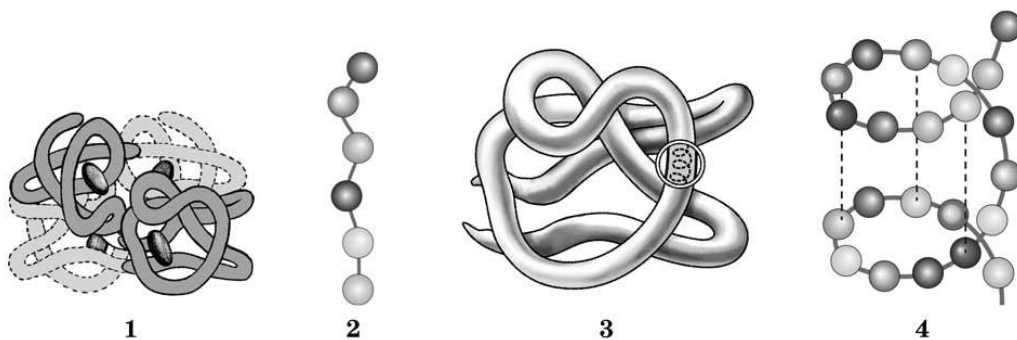
A	B	C

ANSWER _____

6. Establish the sequence of processes occurring during the secretion of a protein substance by a cell. Write the corresponding sequence of numbers in the table.

- 1) modification of the protein molecule
- 2) budding off of the transport vesicle from the ER
- 3) attachment of the vesicle to the cisterna of the Golgi apparatus
- 4) transport of the vesicle with the finished protein to the plasma membrane
- 5) formation of an ER transport vesicle with the synthesized substance

ANSWER _____



7. What number in the figure indicates the protein structure that is synthesized on the ribosome?

ANSWER _____

8. Establish a correspondence between characteristics and the spatial structures of a protein indicated in the diagram above. For each item given in the first column, select the corresponding item from the second column.

CHARACTERISTIC	SPATIAL PROTEIN STRUCTURES
A) peptide bonds are formed	1) 1 2) 2 3) 3
B) exists in the form of folded or helical structures	
C) supported by interaction between radicals	
D) provided by multiple hydrogen bonds	
E) represented by compact globules	

Write the selected numbers in the table under the corresponding letters:

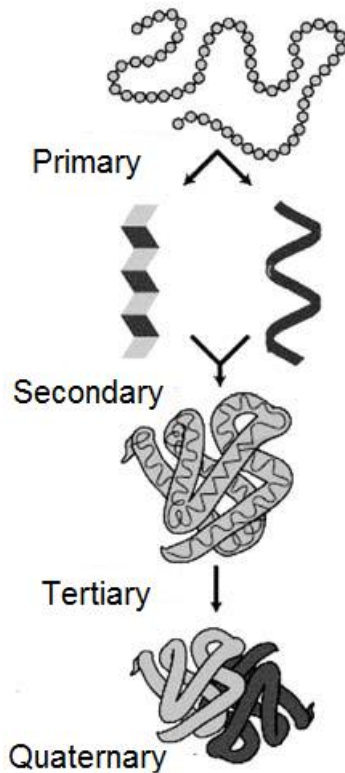
A	B	C	Г	E
2	4	3	4	3

9. Choose three correct answers out of six and write the numbers under which they are indicated in the table.

What characteristics are used in describing the processes in the figure?

- 1) self-duplication of the DNA molecule
- 2) formation of a protein helix
- 3) formation of the quaternary structure of a protein

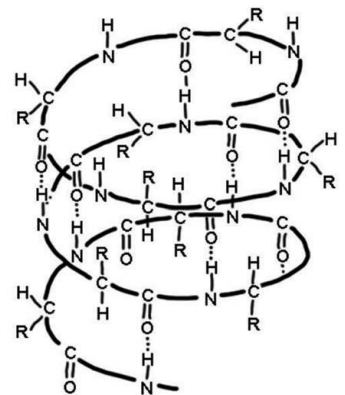
- 4) formation of a globule
- 5) transcription of a polynucleotide chain
- 6) transcription



ANSWER _____

10. Choose three correct answers out of six and write down the numbers under which they are indicated. Which of the following features can be used to describe the properties of the molecule fragment shown in the figure?

- 1) consists of nucleotides
- 2) is held together by hydrogen bonds
- 3) consists of identical monomers
- 4) capable of renaturation
- 5) is synthesized in the Golgi apparatus
- 6) is represented by an α -structure



ANSWER _____

11. Choose three correct answers out of six and write down the numbers under which they are indicated.

What structural features of molecules are characteristic of carbohydrates?

- 1) consist of amino acid residues
- 2) in monomers there is
- 3) consist of carbon, hydrogen, and oxygen atoms
- 4) some molecules have a branched structure
- 5) consist of residues of fatty acids and glycerol
- 6) consist of nucleotides

ANSWER _____

12. Choose three correct answers out of six and write down the numbers under which they are indicated.

Choose the functions that carbohydrates perform in the body.

- 1) catalytic
- 2) transport
- 3) signaling
- 4) structural
- 5) secretory
- 6) energy

ANSWER _____

13. Choose three correct answers out of six and write down the numbers under which they are indicated.

What functions do lipids perform in the cell?

- 1) structural
- 2) energy
- 3) enzymatic
- 4) respiratory

5) storage

6) transport

ANSWER _____

14. Choose three correct answers out of six and write down the numbers under which they are indicated. What functions are characteristic of molecules, an example of which is shown in the figure?



1) catalytic

2) hematopoietic

3) receptor

4) transport

5) photosynthetic

6) reproductive

ANSWER _____

15. Establish the sequence of formation of spatial structures of a protein molecule. Write the corresponding sequence of numbers in the table.

1) packing of the polypeptide chain into a pleated sheet

2) retention of the structure by hydrophobic interaction between amino acid radicals

3) formation of a peptide bond between initial amino acids

4) interaction of several polypeptide chains

5) elongation of the polypeptide chain

ANSWER _____

Task 6.2 Fill in the table: "Organic compounds of the cell"

Small organic molecules	Macromolecules
Sugars	

Fatty acids	
Amino acids	
Nucleotides	

"Carbohydrates"

Task 6.3 Fill in the table: "Carbohydrates"

Carbohydrate	Types	Functions
Monosaccharides $C_n(H_2O)_m$	Hexoses ($C_6H_{12}O_6$): - glucose - fructose - galactose	
	Pentoses $C_5H_{10}O_5$: - ribose - deoxyribose	
Oligosaccharides (2 – 10 glucose molecules)	trisaccharides - tetrasaccharides, etc.	
	- sucrose - maltose - lactose	
Disaccharides - $C_{12}H_{22}O_{11}$		
Polysaccharides	- starch - cellulose - glycogen	

"Lipids"

For reference: Lipids are a complex group of organic compounds that are insoluble in water but soluble in organic solvents.

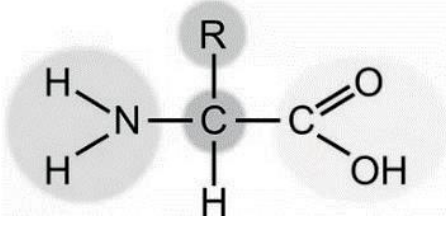
Classification of lipids:	
Simple lipids - upon hydrolysis are split into	Complex lipids - products of hydrolysis, in

alcohols and carboxylic acids.	addition to alcohols and carboxylic acids, are other substances. For example, phosphoric acid, carbohydrates.
- waxes	- phospholipids
- triglycerides	- glycolipids
Lipids also include: - steroids (cholesterol, corticosteroids, sex hormones, vitamin D), - terpenes (carotenoids, phytol, which is part of chlorophylls, vitamin K). Lipids can be a prosthetic group in complex proteins – lipoproteins	

Task 6.4 Fill in the table: "Functions of lipids":

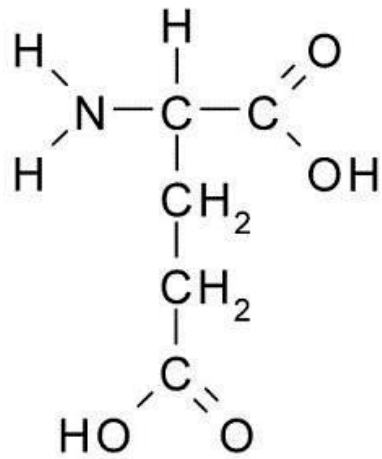
Lipid	Function
phospholipid	
triglyceride	
cholesterol	
glucocorticoid	
chlorophyll	

Task 6.5 Examine the structure of an amino acid. On the right, write the important functional groups that make up the amino acid.

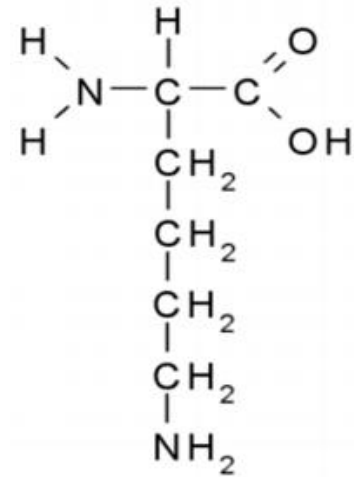
Amino acid	Functional groups
	1- N-terminal region - 2- C-terminal region -

Task 6.5 Using the handout material, determine the type of radical and the properties of amino acids

Glutamic acid	Lysine

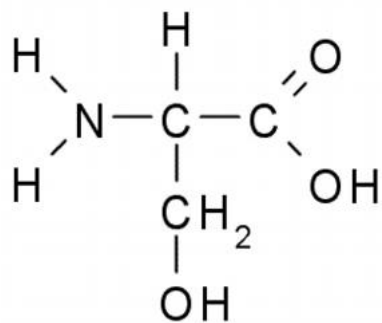


Type of radical -



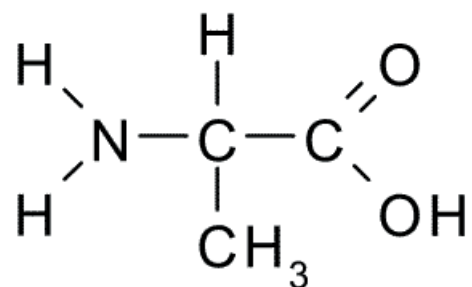
Type of radical -

Serine



Type of radical -

Alanine



Type of radical -

For reference: For humans, amino acids are divided into two groups: essential and non-essential. Non-essential amino acids can be produced by the body itself.

Essential amino acids are not synthesized in the human body, so they must come with food.

ESSENTIAL AMINO ACIDS

Amino acid	Role in the body	Sources	Signs of deficiency
Valine	stimulates mental activity, muscle activity and coordination of movements, participates in metabolic processes in muscles, strengthens muscles	Nuts, seeds, meat, poultry, eggs, mushrooms, peanuts, soy and other legumes, caviar, hard cheeses, cottage cheese	Impaired coordination of movements, increased sensitivity to stimuli
Isoleucine	Participates in the synthesis of hemoglobin, regulates blood sugar levels, determines physical and mental endurance	Almonds, cashews, chicken, soy, lentils, chickpeas, eggs, fish, liver, meat, rye, seeds	Increased excitability, fatigue, dizziness, rapid heartbeat, sweating
Leucine	Participates in the synthesis of growth hormone, promotes regeneration of bones, skin, muscles, lowers blood sugar levels	Meat, fish, brown rice, beans, lentils, soy, nuts, wheat seeds	Slow recovery after injuries and surgeries
Lysine	Participates in the synthesis of collagen, antibodies, hormones, enzymes, promotes tissue repair, calcium absorption	Fish, red meat, dairy products, cheese, eggs, wheat, nuts, soy	Irritability, fatigue, weakness, decreased appetite, growth retardation
Methionine	Antioxidant, participates in the synthesis of collagen and other proteins, protects joints, provides body detoxification,	Dairy products, meat, nuts, bean eggs, lentils, soy, garlic, onions, seeds.	Irritability, anger, hyperactivity in children
Threonine (in vegetarianism – typical	Participates in the synthesis of collagen and elastin, in fat and protein metabolism, normalizes liver function, helps boost	Dairy products, meat, eggs, in wheat, beans.	Disruption of the heart, nervous system, weakness of skeletal

deficiency)	immunity		muscles
Tryptophan	Is converted into serotonin (a neurotransmitter) that causes mental relaxation and creates a feeling of emotional well-being	Oats, bananas, nuts, vegetable oils, dairy products, cheese, fish, poultry, meat	Depression, anxiety, insomnia, impaired attention, hyperactivity, migraine, headaches, tension
Phenylalanine	Participates in the synthesis of the neurotransmitter dopamine (a precursor to adrenaline and noradrenaline), reduces pain, helps improve mood, memory and learning, suppresses appetite	Meat, fish, poultry, soy and other legumes, eggs, cheese, cottage cheese, milk	Menstrual and other pains, migraine, arthritis, Parkinson's disease, hand tremors from hangover

Task 6.7 Fill in the table: "Functions of proteins"

Function	Proteins (give at least 2 examples)
Structural	
Enzymatic	
Signaling (hormones)	
Transport	
Protective	
Contractile (motor)	
Storage	

CLASSROOM WORK

Work 6.1 Rare amino acids

Fill in the table: "Functions of rare amino acids".

For reference: Some proteins contain rare amino acids, due to which they perform specific functions. Collagen — a very strong protein of tendons — includes rare amino acids (hydroxylysine, hydroxyproline), which are absent in other proteins. It is these amino acids that give the protein special properties (strength and elasticity). Twenty-five human proteins include selenocysteine in their primary structure. These proteins possess the properties of enzymes – selenoenzymes, which use selenocysteine as a catalytic fragment in their active sites. Selenoenzymes, for example, glutathione peroxidases, play an important role in protecting the body from oxidative damage. Glutathione peroxidases catalyze the reduction of lipid peroxides into corresponding alcohols and the reduction of hydrogen peroxide to water.

Amino acid	Is a part of	Function
Hydroxyproline (proline derivative)	Collagen — a connective tissue protein	
Selenocysteine (cysteine derivative)	Glutathione peroxidase	
Thyroxine (T4) Triiodothyronine (T3) (tyrosine derivatives)	Thyroglobulin	

Levels of organization of the protein molecule

For reference:

Primary – determined by the amino acid sequence in the polypeptide chain.

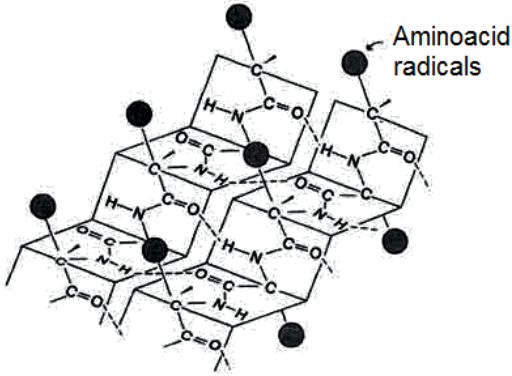
Secondary – represented by an α -helix and β -sheet. Tertiary – is present in globular proteins upon the folding of helical and non-helical regions into a three-dimensional spherical formation. The process of folding the secondary structure of a polypeptide into a globule is called folding. Proteins called chaperones take part in this process, helping to complete the folding along the most energetically favorable pathway.

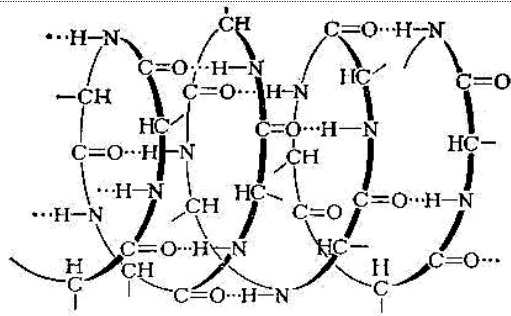
Quaternary – in globular proteins, several polypeptide chains with a tertiary structure can be combined into a common rounded structure. In fibrillar proteins with a helical secondary structure, several helices can twist together.

Work 3.2 Write the reaction for the formation of a peptide bond in a dipeptide. What type of chemical bond does it belong to?

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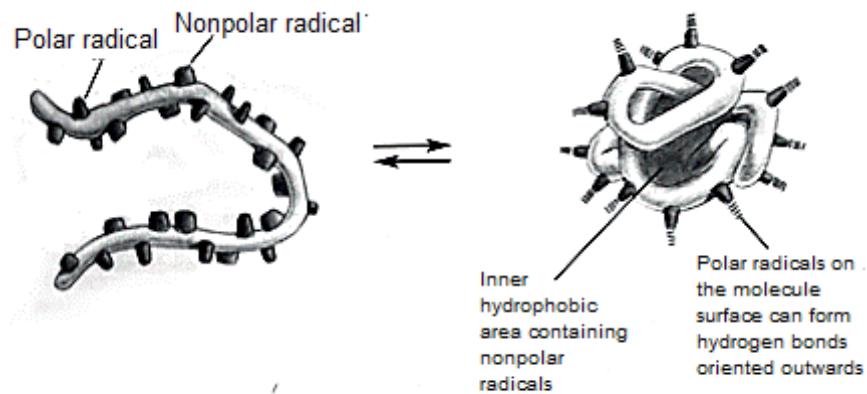
Work 3.3 Determine the type of secondary structure of a polypeptide fragment and the bonds that stabilize these structures

Structural formula of a polypeptide	Type of secondary structure. Stabilizing bonds / what they connect
	



Work 3.4 Using the handout material, determine the arrangement of radicals in a fragment of a protein molecule (on the surface or inside the molecule) consisting of an amino acid sequence, by placing the numbers 1 (on the surface) or 2 (inside) under the name of the amino acid.

Amino acid sequence: Leu-Lys-Val-Leu-Lys-Ile-Asp-Ile-Met-His-Cys



List the bonds stabilizing the tertiary structure of the protein:

Your answer:

Work 3.5 Eukaryotic nuclear DNA is located in the nucleus in a complex with proteins – histones.

Explain, using the diagram, the predominance of the following amino acids in proteins: arginine, histidine, and lysine.

Diagram illustrating the assembly of a nucleosome:

- Individual histone proteins: H3, H4, H2A, H2B.
- Assembly steps:
 - H3 and H4 form an **H3-H4 Dimer**.
 - H2A and H2B form an **H2A-H2B Dimer**.
 - The two dimers combine to form an **H3-H4 Tetramer**.
 - The tetramer and the H2A-H2B dimer combine to form the **Octamer**.
- The final structure is the **Nucleosome**, consisting of DNA wrapped around the octamer core.

Your answer:

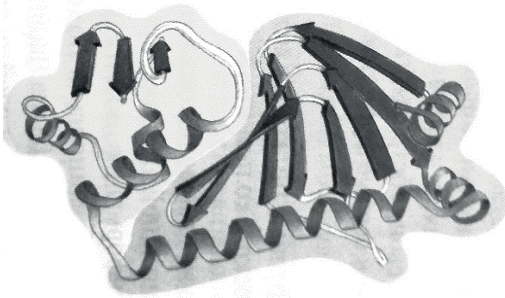
Work 3.6 A domain is a small section of any structure. Protein domains are compact regions of a polypeptide with stable folding as part of the tertiary structure of a protein.

Determine how many domains the bacterial regulatory protein CAP* consists of?

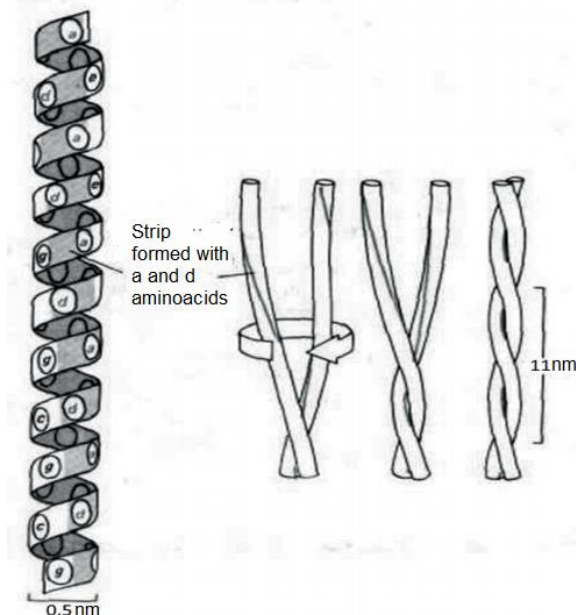
What are these domains represented by?

CAP* protein is involved in transcription regulation

Your answer:



For reference: CAP protein (CAP from eng. catabolite activator protein) is an activator protein of catabolite operons regulating transcription in prokaryotes.



Work 3.7 Two or three α -helices twisted around each other form a particularly strong structure called a "coil of coils", or supercoil.

It is formed by α -helices in which non-polar radicals are located in turns under each other on one side of the helix. α -keratin, which is part of hair, the epidermis of the skin, and the cytoskeleton, has such a structure. In a single α -helix, non-polar amino acids "a" and "d" are close to each other on the surface of the cylinder, forming a strip.

Task: Using the diagram, explain due to what α -helices can wrap around each other?

Your answer:

Work 3.8 The main function of apolipoprotein E is the function of a ligand binding low-density lipoproteins (LDL) and triglycerides to liver cell receptors, where they are processed, as a result, the removal of excess LDL and triglycerides from blood plasma is achieved. There is a mutation in this protein that changes the charge of one amino acid. As a result, the properties of the protein change and it loses the ability to bind with LDL and triglycerides. It is believed that this increases the

protein aggregates.

A prion protein, possessing an abnormal three-dimensional structure, is capable of directly catalyzing the structural transformation of a homologous normal cellular protein into a similar (prion) one by attaching to the target protein and changing its conformation. The accumulation of prion protein is accompanied by the aggregation of highly ordered amyloid fibrils, which leads to cell death. The released prion protein penetrates neighboring cells, causing their death as well.



Normal protein



Prion protein

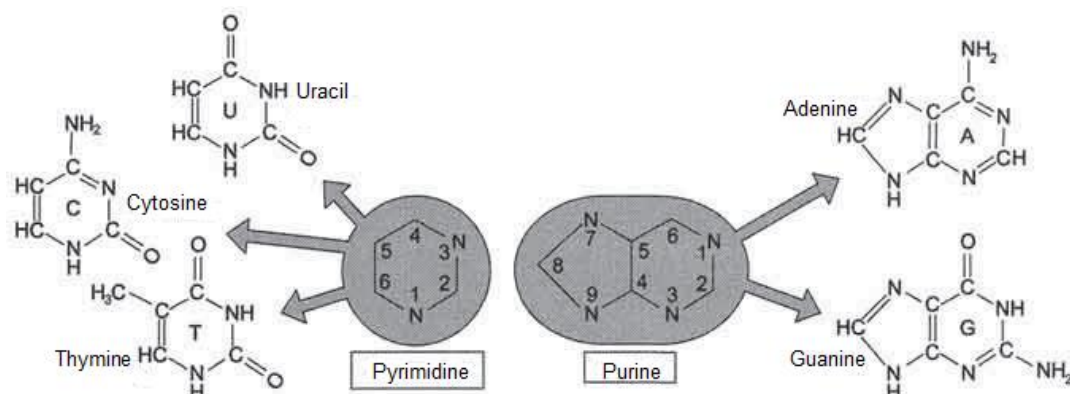
For reference: Amyloidosis is a violation of protein metabolism, accompanied by the formation and deposition in tissues of a specific protein-polysaccharide complex - amyloid.

Task: Using the diagram, explain how the conformation of the PrPC protein (A) changed, leading to the appearance of the prion protein PrP^{Sc} (B)

Your answer:

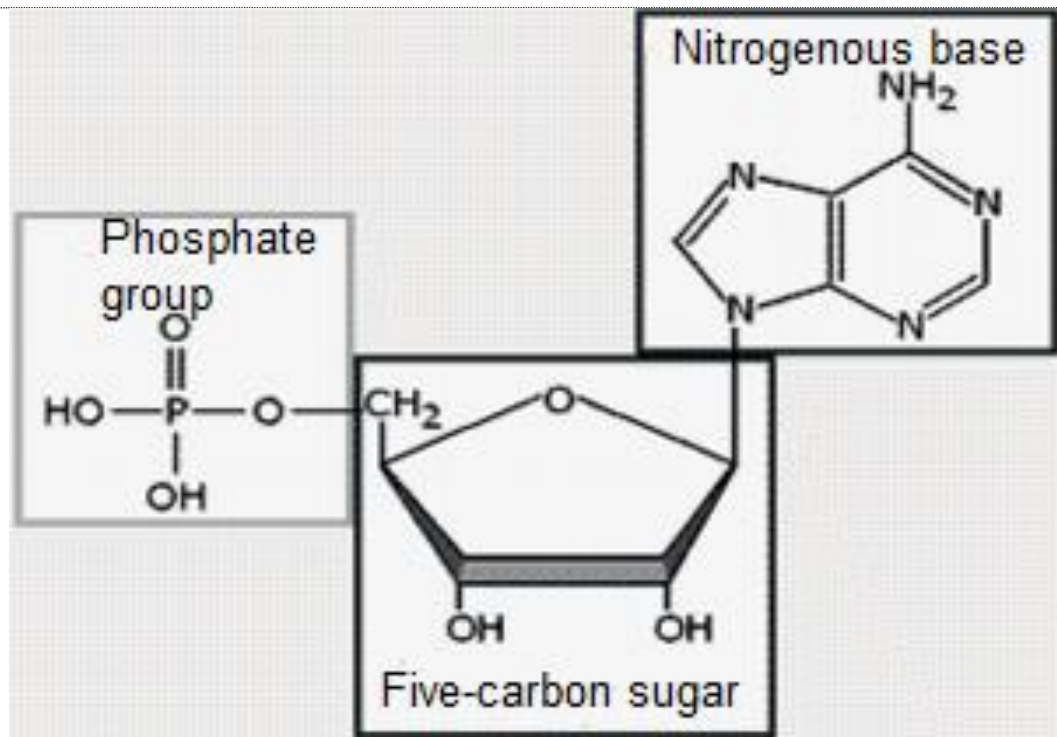
Work 3.10 Structure of the nucleotide

Nucleotides include nitrogenous bases: purine or pyrimidine, a sugar, and a phosphoric acid residue. Using the diagram, examine the structure of the nucleotide



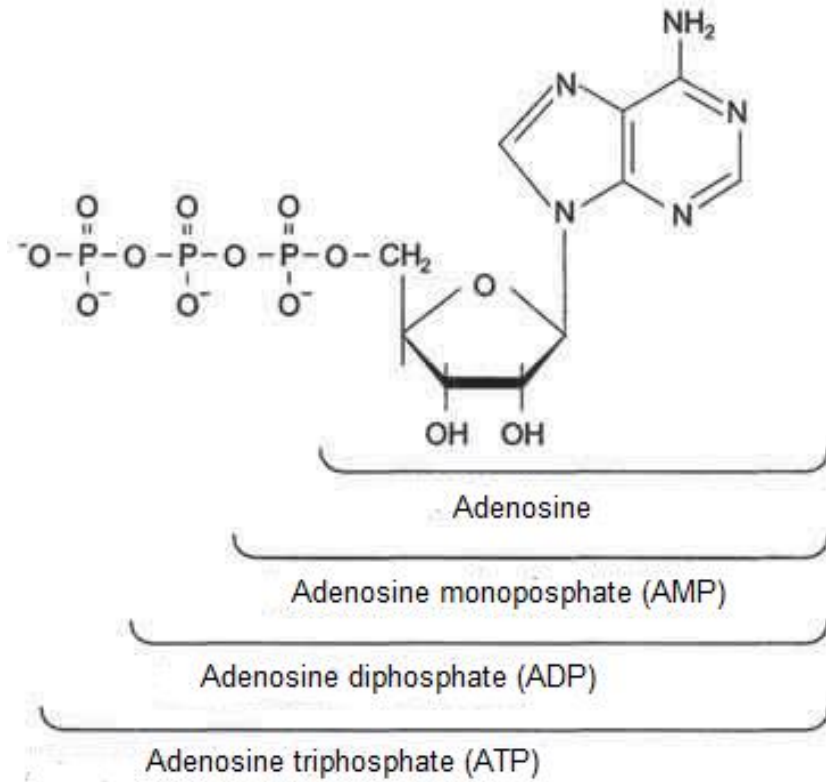
Your answer:

Task: using the diagram, name the nucleotide, number the carbon atoms in the sugar.



Your answer:

Work 3.11 Using the diagram, name the pentose, nitrogenous base and the bonds connecting two phosphoric acid residues with adenosine monophosphate



Your answer:

Grade for the class _____

Teacher's signature _____

Date _____

Date: _____

TOPIC: 7 CELL MEMBRANE. STRUCTURE, PROPERTIES AND FUNCTIONS OF THE CELL MEMBRANE.

INDEPENDENT STUDENT WORK

Task 7.1 Give definitions for the terms:

Plasmalemma -	
Membrane lipids -	
Membrane proteins -	
Enzymes -	
Glycocalyx -	
Compartments -	
Passive transport	
Simple diffusion -	
Facilitated diffusion -	
Osmosis -	
Aquaporins -	

Active transport	
Vesicular transport	
Endocytosis	
Phagocytosis -	
Pinocytosis -	
Exocytosis -	

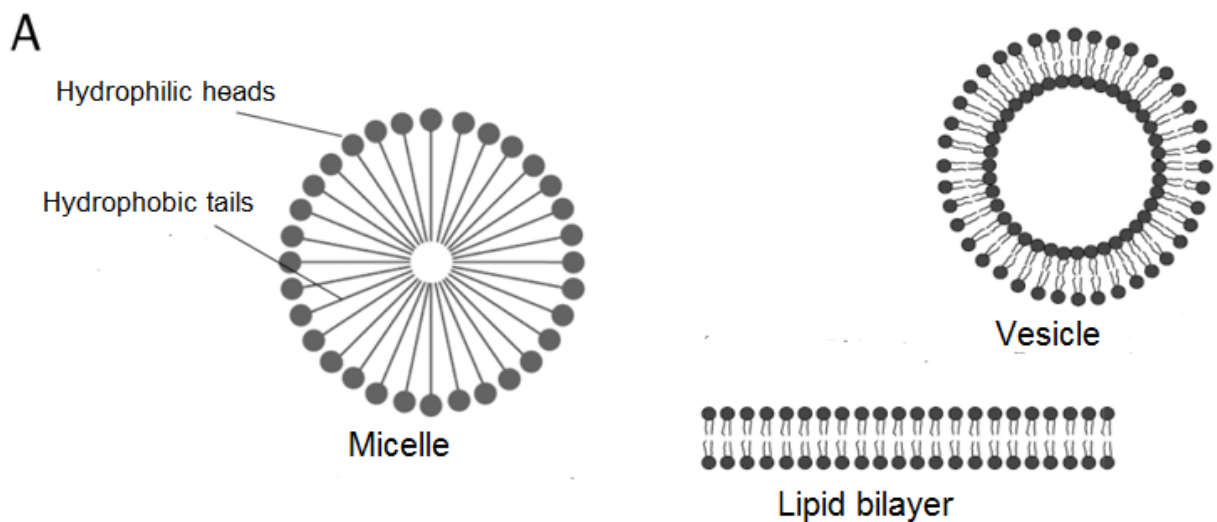


Fig. 5.3. Lipid molecules' ways of selforganization in solution

Phospholipids – the basis is phosphoric acid, having the formula H_3PO_4 , the valence of phosphorus is V. In phosphoric acid, four oxygen atoms are attached to the phosphorus atom, one by a double bond, and all the rest by single bonds. Hydrogen atoms are attached to the latter. When phosphoric acid is in solution, hydrogen atoms (or rather, protons) can tear off, turning phosphoric acid into an anion. Here, it must be borne in mind that "phosphoric acid" and "phosphate" (i.e. its anion or salt) are almost synonymous in biochemistry. In the vast majority of cases, these concepts

are freely interchanged. Very often the name "phosphoric acid" is replaced by "phosphate" simply for brevity.

Phosphoric acid can participate in the formation of esters in the exact same way as carboxylic acids. An ester of glycerol, two fatty acids, and phosphoric acid is called a phospholipid. This is an extremely important class of compounds for biology. It can be said that a phospholipid is a fat in which, instead of one of the fatty acid residues, a phosphate is attached in the same way. Such a molecule consists of a hydrophilic "head" (including glycerol and phosphate residues) and two hydrophobic "tails" (fatty acids). There are also additional side chains near the phosphate; they are different for different phospholipids.

Two particularly widespread phospholipids are phosphatidylcholine and phosphatidylserine. In phosphatidylcholine, the additional side chain near the phosphate is choline, a small nitrogen-containing organic molecule. And in phosphatidylserine, the amino acid serine is attached to the phosphate. We should not go into other biochemical details here; the general properties of phospholipids are much more important anyway. And they consist in the fact that any phospholipid is a pronounced amphiphilic molecule, consisting, simply put, of one large hydrophilic "head" and two long hydrophobic "tails".

A micelle is a spherical accumulation where the "tails" point inward, minimizing contact with water, and the "heads" point outward. A micelle contains nothing but the lipid molecules themselves. Micelles are particularly easily formed from molecules where the "head" is larger in diameter than the "tail", that is, the molecule has the shape of a cone. Such are, for example, fatty acid molecules;

History of the discovery of micelles. The hypothesis about the existence of micelles was first put forward by the Canadian chemist James William McBain in 1913. He found that solutions of certain organic acids, such as palmitic acid, exhibit high electrical conductivity despite their apparent insolubility in water. McBain suggested that colloidal particles are formed in the solution, which can conditionally be called "micelles". This term comes from the Latin "mica" – crumb. However, scientists began to truly study the structure of micelles and the mechanisms of their formation only in the mid-20th century. A great contribution was made by the work of the Swedish chemist Gunnar Aniansson in the 1970s. He studied the kinetics of micellization in detail and proposed the first quantitative models of this process.

A bilayer, in which two layers of neatly aligned lipid molecules are facing each other with their "tails" and with their "heads" towards the water column. In this case, the hydrophobic regions of both layers interact with each other without touching the water. A bilayer is most easily formed if the width of the "head" and "tail" of the molecule (or all its "tails" together) is the same, that is, the molecule is cylindrical. This is exactly how phospholipid molecules are structured;

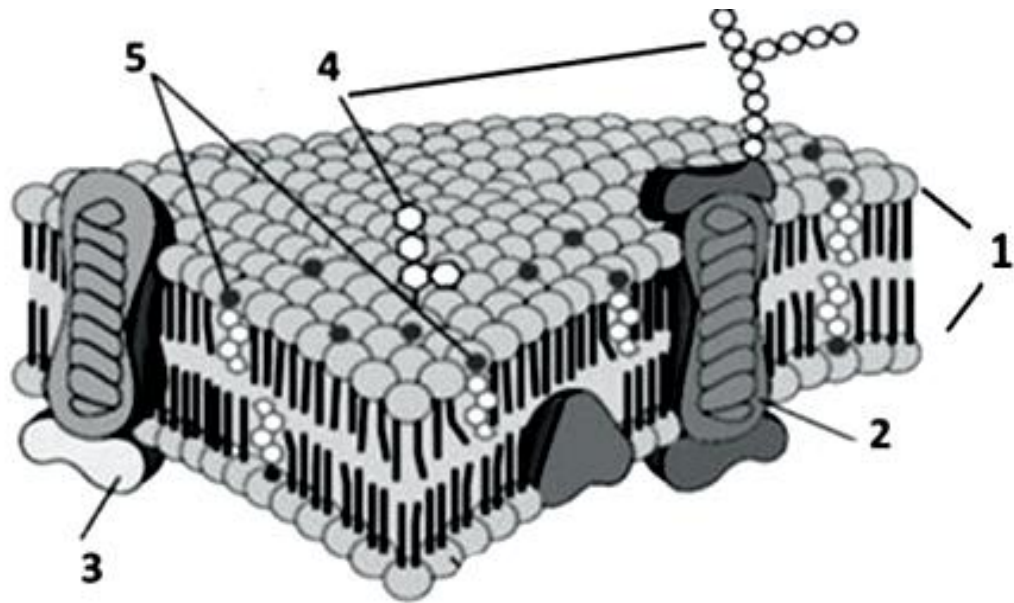
A vesicle is a bubble representing a bilayer closed into a sphere. Such closure occurs quite easily, because the edges of a bilayer are always unstable – after all, the hydrophobic "tails" are exposed there. In a vesicle, there are no more free edges. Inside the vesicle, there is a cavity filled with the same water as outside.

So, fatty acids more readily form micelles, and phospholipids form bilayers that close into vesicles. This is exactly what the cell membrane is—a bilayer. It consists of two layers of phospholipids facing each other with their hydrophobic "tails". (In fact, this is not how the membrane of absolutely all cells is structured, but only the vast majority, but we'll talk about exceptions later.) As a rule, the

cell membrane does not have any free edges, it is completely closed. That is, the entire cell membrane is, in a sense, one overgrown vesicle.

Let's repeat once again: a typical cell membrane is a phospholipid bilayer. This statement, which might have seemed completely mysterious a few pages ago, is now clear to us. And an even more obvious thought can be added to it: where there is no cell membrane, there is no cell at all. After all, you can only talk about a cell when there is a clear boundary separating the intracellular space from the external environment. Thus, the history of the emergence of cellular life forms is largely precisely the history of the emergence of lipid membranes.

Task 7.2 Describe the diagram of the structure of the cell membrane and describe the functional purpose of each component.



1-

4 -

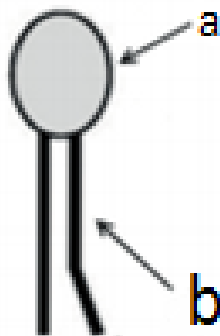
2-

5 -

3 -

According to the fluid mosaic model of the membrane, proposed in 1972 by Jonathan Singer and Garth Nicolson, a biological membrane is:

Your answer:



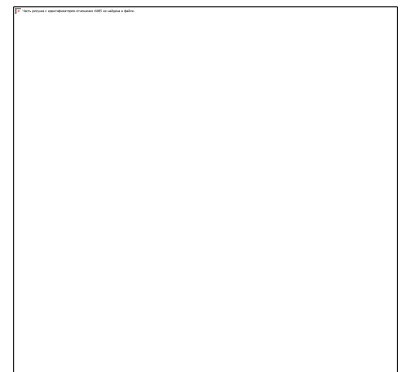
The diagram shows the structure

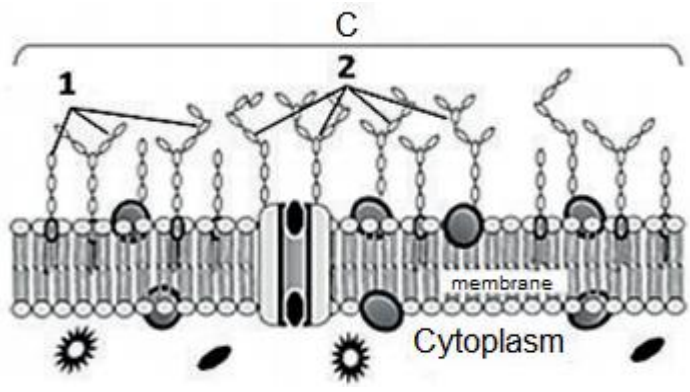
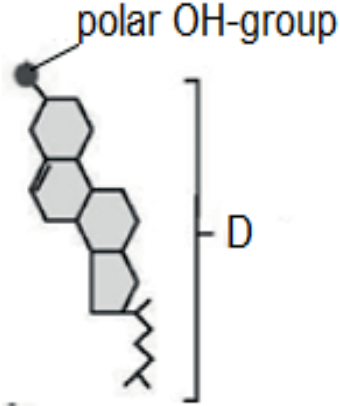
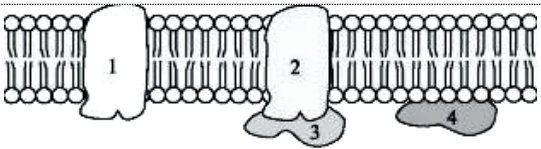
—

$a -$

$$b -$$

functions -



	
C -	D -
1 -	Functions -
2 -	
Functions -	
	1 - 2 - 3 - 4 -

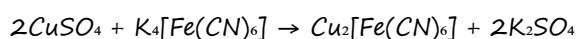
CLASSROOM WORK:

Work VII.1. Obtaining an artificial Traube "cell"

Equipment: crystals of potassium hexacyanoferrate (II) $K_4[Fe(CN)_6]$ (yellow prussiate of potash); 0.5% aqueous $CuSO_4$ solution in a test tube; tweezers, magnifying glass.

Background information: one of the products of the chemical reaction between the proposed substances has a property characteristic of living cell membranes.

Semipermeability - the ability to selectively pass substances through a membrane. Plant cell membranes have a similar property. Upon the interaction of yellow prussiate of potash with copper sulfate, a semipermeable copper (II) hexacyanoferrate is formed. This effect was discovered by the German chemist and physiologist Moritz Traube. His work showed that it is possible to find such chemical compounds that, like a plant cell, will absorb some substances from the environment and secrete others:



The concentration of yellow prussiate of potash inside the cell is greater than the concentration of copper sulfate outside. As a result, water enters the cell, thereby enlarging it until the concentrations of yellow prussiate of potash and copper sulfate equalize. Due to the pressure, the membrane of copper (II) hexacyanoferrate is constantly breaking. At the site of the rupture, copper sulfate and

yellow prussiate of potash interact again, and the film forms again. Therefore, the Traube cell grows unevenly.

Procedure:

1. Select a large crystal of yellow prussiate of potash and use tweezers to place it in a test tube with CuSO_4 solution. Observe the result. Choose the time when the changes in the test tube are most clearly visible.
2. Write down the equation of the chemical reaction carried out (4 points):
3. Using the proposed diagram, finish drawing the observed picture.

Indicate on the figure the distribution of substances that entered into the reaction and the products of the chemical reaction. Use an arrow to indicate the direction of water flow

1. What is the reason for the observed phenomenon?
2. The concentration of the copper (II) sulfate solution relative to the $\text{K}_4[\text{Fe}(\text{CN})_6]$ solution can be considered:
 - a) hypertonic
 - b) isotonic
 - c) hypotonic
 - d) osmotic



CONCENTRATION



Work VII.2. Accumulation of methylene blue in Elodea cells.

One of the most important properties of the membrane is semipermeability, i.e., the ability to easily pass water and retain dissolved substances. However, the plasmalemma does not have ideal semipermeability: it passes not only water, but also many substances, and some of them at a significant rate. Such substances include methylene blue, which penetrates plant cells quite quickly.

The tissues of some plants are able to accumulate a large amount of methylene blue up to its almost complete extraction from the external solution due to the chemical binding of the dye by tannins contained in the cells, and small blue crystals are often formed.

Dyes whose colored part is an anion (acid dyes) do not penetrate living cells. Some basic dyes, the colored part of which is a cation, penetrate living cells; they are called vital (intravital) dyes. Of the vital dyes, neutral red (neutral red) is most often used to assess cell viability.

Materials and equipment: 1) Elodea shoots; 2) methylene blue solution 1:50,000 (20 mg in tap water); 3) KNO₃ solution in a dropper; 4) tweezers; 5) test tube rack (2 pcs.); 6) microscope; 7) glass slide and coverslip; 8) strips of filter paper. 1 M

Procedure. Fill two test tubes with methylene blue solution. Place 2–3 Elodea shoots in one, leave the second as a control. After 2–3 hours (or after a day), note the change in the color intensity in the vessel with plants compared to the control (examine against a light background). Place 1–2 intensely colored leaves on a glass slide in a drop of KNO₃ solution and cover with a coverslip, and after 15–20 minutes examine under a microscope at high magnification. 1 M

Task: Draw the progress of the work (Fig.7) and a plasmolyzed cell, marking with colored pencils the place of dye accumulation in different parts of the cell (Fig.8). Draw a conclusion.

Objective -----

Procedure:



Fig.7. Stages of work

Fig.8. Plasmolyzed cell

Conclusion: -----

Answer the questions in writing:

1. In which part of the cell does methylene blue accumulate?

2. How to explain the absence of reverse diffusion of the absorbed dye from the cells into the external solution?

3. Do the cells remain alive after the accumulation of methylene blue in them? Justify your answer.

Work VII.3. Intravital staining of cells with neutral red.

Materials and equipment: 1) onion bulb, leaves of various plants; 2) 0.01% solution of neutral red in a dropper with a medium reaction close to neutral (the solution is prepared immediately before use: a 0.1% solution of neutral red prepared in distilled water is diluted with tap water); 3) KNO₃ solution in a dropper; 4) scalpel; 5) razor blade; 6) dissecting needle; 7) microscope; 8) slides and coverslips; 9) glass rod; 10) cup with water; 11) pieces of filter paper; 12) colored pencils. 1 M

Like methylene blue, neutral red dye is able to penetrate living cells and accumulate in them in large quantities. With a short stay of cells in a solution of neutral red, the cytoplasm does not die off, which can be verified by causing plasmolysis of stained cells (only living cells can be plasmolyzed).

Neutral red is a two-color indicator: in an acidic environment ($\text{pH} < 6$) it is crimson-colored, in an alkaline one it is yellow.

To understand the results of this work, it must be borne in mind that in a solution with a pH of about 7, neutral red is in the form of undissociated molecules that are highly soluble in membrane lipids, whereas in an acidic medium ($\text{pH} < 6$), this substance dissociates into ions that are poorly soluble in lipids.

Neutral red molecules are not retained in the cytoplasm of a living plant cell, but with the participation of the Golgi apparatus and tonoplast are actively excreted into the vacuole. Therefore, in living cells, the dye accumulates in the vacuole, while the nucleus and cytoplasm remain uncolored. In dead cells, on the contrary, the cytoplasm and especially the nucleus adsorb the dye, but it is not

retained in the vacuolar sap. Therefore, in dead cells, the nucleus is brightly colored, to a lesser extent the cytoplasm, and the vacuoles remain uncolored.

At low magnification, pink and pinkish-orange vacuoles that have accumulated the dye are clearly visible. The intensity of their color in adjacent cells can be different, as cells differ in the rate of dye accumulation. The lack of color in the cytoplasm and nucleus of these cells is easy to detect at high magnification.

The stained cells are "killed" by holding the glass slide over the flame of a burner until bubbles begin to appear under the coverslip. Then the preparation is again examined under a microscope.

After the death of the cells, their color changed: the nucleus became brightly colored, the cytoplasm located in a thin layer along the walls less brightly, and the color disappeared in the vacuoles.

When live epidermal cells are exposed to a dye solution prepared in distilled water, whose pH is 5.6 and lower than that of tap water, the picture is different: the vacuoles of living cells, the cytoplasm and the nucleus also remain uncolored, only the cell walls are colored. The same is observed when staining slightly damaged or traumatized cells due to careless removal of the epidermis.

Procedure. Prepare 2-3 sections of the epidermis of onion scales or leaves of any other plants and place them on a glass slide in a large drop of neutral red solution without covering with a coverslip (with good air access, staining occurs faster). After 10 - 15 minutes (no more), suck off the dye solution with filter paper, transfer the sections into a drop of water, cover with a coverslip and examine under a microscope. Replace the water with KNO_3 solution and continue observations at high magnification.¹ M

Task: draw a plasmolyzed cell (Fig. 9), noting which part is stained with dye (cell wall, cytoplasm or vacuole) and in what color (color with a colored pencil).

Objective -----

Procedure: -----

Fig.9. Plasmolyzed cell

Conclusion: -----

Answer the questions in writing:

1. Is the permeability of the cytoplasm to neutral red great?

2. What is the reaction (pH) of the contents of the studied cells?

3. How to explain the accumulation of neutral red in cells?

Work VII.3. Permeability of cells of different ages to urea.

Permeability is the rate of penetration of a substance through a membrane. The permeability of cytoplasmic membranes for most dissolved substances is very low, but some substances, including urea, penetrate membranes quite quickly.

When plant cells are immersed in a hypertonic solution of urea, plasmolysis is observed due to the withdrawal of water from the cells. However, with a prolonged stay in this solution, the plasmolyzer molecules penetrate into the cell sap, the concentration of which increases, as a result of which water re-enters the cells. Spontaneous deplasmolysis occurs; the time interval from immersion in the solution to the end of deplasmolysis can be used to determine the permeability of the cytoplasm to urea.

Procedure. Apply a large drop of urea solution to a glass slide and immerse a leaf that has not finished growing from the upper part of the Elodea shoot into it, noting the time. Cover the preparation with a coverslip and immediately begin observation under the microscope. Note the different speed of onset of convex plasmolysis in the lower (growing) and upper parts of the leaf, which indicates an unequal viscosity of the cell cytoplasm.¹ M

Continue monitoring for another 15-20 minutes. Ensure that the urea solution does not dry out by occasionally introducing new drops under the coverslip (or smearing the edges of the coverslip with Vaseline). Note the time of onset of spontaneous deplasmolysis in cells of different zones of the leaf. Fill in Table 2, draw conclusions.

Objective -----

Materials and equipment: 1) Elodea branches; 2) urea solution (60 g/l) in a dropper; 3) microscope; 4) slides and coverslips; 5) tweezers; 6) dissecting needle; 7) pieces of filter paper; 8) Vaseline.¹ M

Procedure:

Table 2

Elodea leaves	experiment start time	time of onset of plasmolysis	time of onset of deplasmolysis	time of permeability for urea
Upper part of the Elodea				

leaf				
Lower part of the Elodea leaf				

Conclusions:

Answer the questions in writing:

1. What are the causes of spontaneous deplasmolysis?

2. How to explain the unequal rate of deplasmolysis in cells of different zones of the leaf?

3. Is there a connection between the permeability of the cytoplasm and its viscosity?

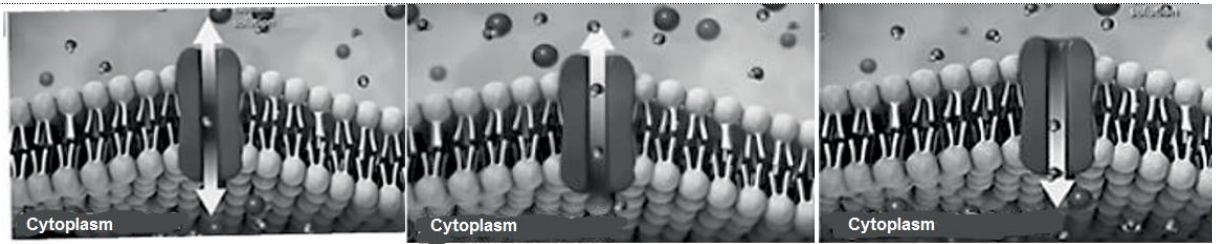
Task 7.4 Fill in the table: "Main properties and functions of biological membranes"

Properties and functions of the membrane	Explanations
Fluidity -	
Semipermeability -	
Dynamism -	
Bounding -	
Protective/barrier -	
Transport -	
Receptor -	
Catalytic -	
Formation of intercellular contacts	

Grade for the class -----

Teacher's signature -----

Date -----



A -

B -

C -

Type of transport of substances -

Task 8.3. Situational task

What is your assumption of what will happen to erythrocytes if they are placed in a 0.34% NaCl solution? Justify your answer.

Your answer:

For reference: Osmotic hemolysis is the phenomenon of rupture of erythrocytes in a hypotonic solution as a result of the destruction of the protein-lipid membrane of erythrocytes.

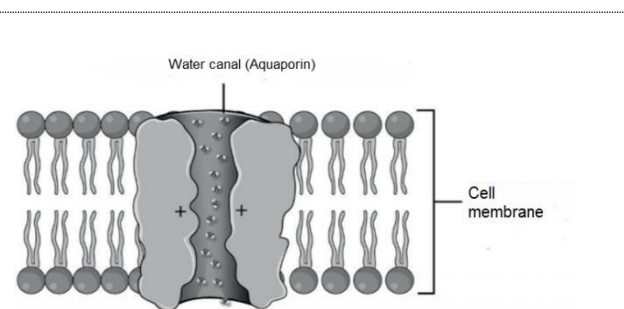
Task 8.4. Water channels of the membrane

The diagram shows a water channel - an aquaporin. It is known that aquaporins are involved in almost all physiological processes of the body. Using information resources, give specific examples confirming the functional significance of aquaporins for the body.

Your answer:

Specify what type of transport transport through aquaporins refers to and what the driving forces of this process are.

Your answer:



Examples:

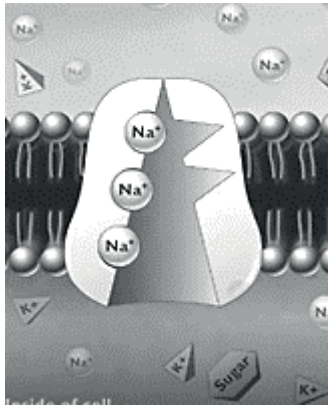
Type of transport -	
Driving forces -	

Task 8.5. Situational task

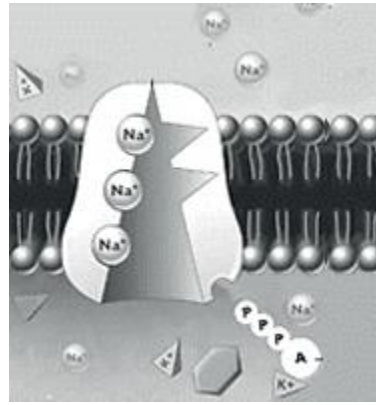
If this enzyme is inhibited, the cell loses viability, because the concentration between the intracellular and extracellular environment equalizes and the cell becomes non-viable. This is the main enzyme that forms the electrical potential on the membrane. What enzyme are we talking about?

Your answer:

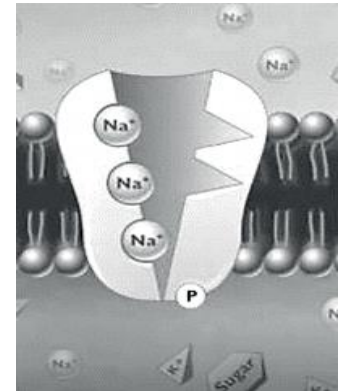
Describe step by step the work of the protein you specified:



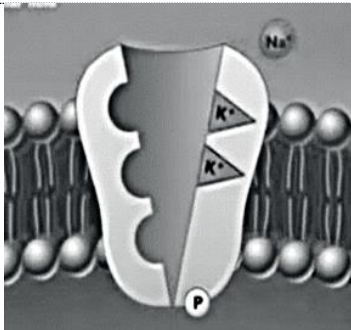
1 -



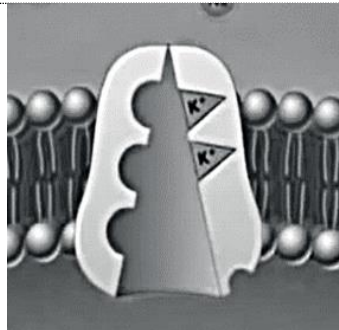
2 -



3 -



4 -



5 -



6 -

CLASSROOM WORK

For reference: Protoplast (from the ancient Greek πρῶτος - "first" + πλαστός - formed, molded, etc.)

– the internal content of a living bacterial, fungal or plant cell, excluding the outer cell wall, but together with the cell (plasma) membrane. др.-греч.первыйрастительнойклеткиклеточной (плазматической) мембраной

The protoplast includes:

✓ cytoplasm, цитоплазму

✓ nucleus, ядро

✓ all organelles органеллы

✓ cell membrane. That is, protoplasm and membrane. клеточную

мембрану протоплазму

In 1839, J. Purkinje introduced a new term "protoplasm", i.e., the living content of the cell.

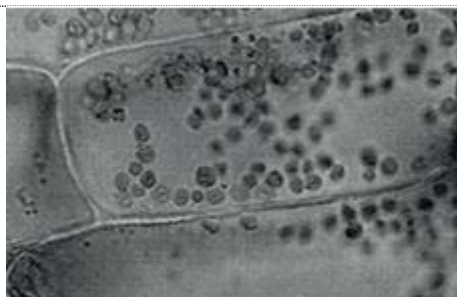
The protoplast is a heterogeneous system that consists of a nucleus and cytoplasm. The cytoplasm, in turn, consists of organelles and cytosol. Cytosol or hyaloplasm is the internal environment of the cell in which organelles are immersed. On the outside, the protoplast is surrounded by the plasmalemma. Plant protoplasts are membrane-bound cytoplasmic formations possessing intracellular organelles and characterized by structural integrity and the ability to carry out active metabolism, as well as biosynthesis and energy transformation reactions.

Work 8.1. Study the process of plasmolysis and deplasmolysis in the cells of an Elodea leaf.

First, study the structure of normal Elodea leaf cells. To do this, prepare a temporary slide: cut off about half of a leaf from an Elodea branch; Place a drop of water on a glass slide and place a piece of the leaf in it. Cover with a coverslip. Examine the slide first under low and then under high magnification. At a magnification of x40, strongly elongated, almost rectangular cells with a thick colorless shell are clearly visible. A lot of round-oval green bodies are visible in the cytoplasm of the cells. These are chloroplasts. Nuclei are not visible in unstained cells.

Examine the cells near the central vein of the leaf. In them you can observe the movement of cytoplasm and plastids along the walls (cyclosis). Draw a few cells in the normal state.

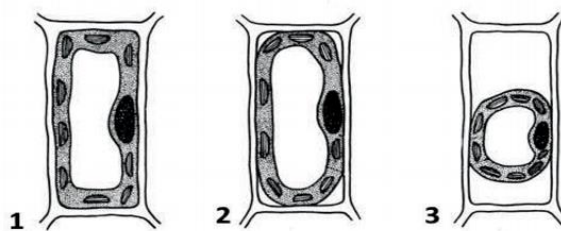
The figure should indicate: 1) membrane; 2) cytoplasm; 3) chloroplasts.



Chloroplasts in a plant cell

X400

For reference: Plasmolysis is the process of separation of the cytoplasm from the outer membrane upon osmotic loss of water by the cell.



1 - cell in a state of turgor; 2 - beginning of plasmolysis; 3 - complete plasmolysis.

Deplasmolysis is the return of plant cells from a state of plasmolysis to their original state, characterized by normal turgor. (deplasmolysis occurs due to the entry of water from the environment into the cell).

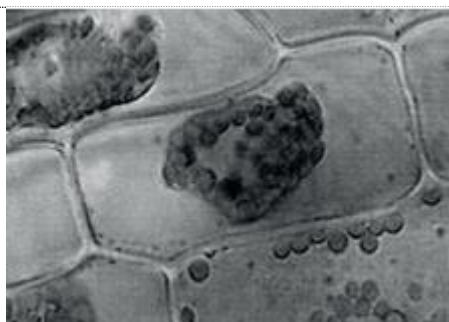
To study the plasmolysis process in the prepared slide, it is necessary to replace the water with a hypertonic solution of sodium chloride. For the replacement to occur gradually, apply a drop of a 10% sodium chloride solution to one edge of the coverslip, and put a strip of filter paper on the opposite side (it will absorb part of the water). Observe the state of the cytoplasm in the cells under high magnification of the microscope. Water from the cytoplasm of the cells passes into the surrounding hypertonic medium, the volume of the cytoplasm decreases, and it begins to move away from the cell walls.

Gradually, the cytoplasm completely moves away from the cell wall and takes the shape of a sphere located in the center of the cell – plasmolysis occurs.

If water is introduced under the coverslip after this, the hypertonic solution will turn into a hypotonic one. Water will enter the cytoplasm, as a result of which the latter will take up its previous volume, deplasmolysis will occur, and the cell will acquire normal turgor.

Draw a few cells after plasmolysis under a 40x objective magnification.

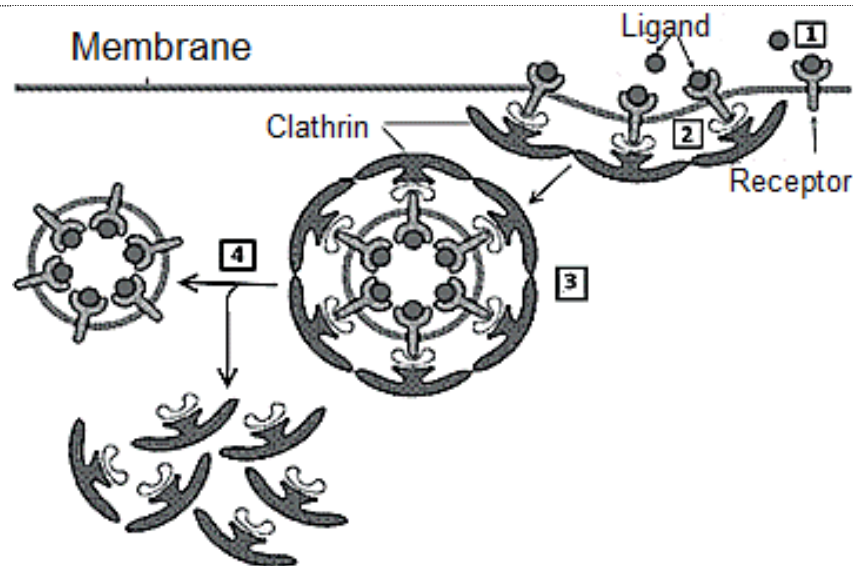
The figure should indicate: 1) cell wall; 2) cytoplasm; 3) chloroplasts.



X400

Work 8.2. Study the diagram.

Task: Using the handout material, determine what process is depicted on it? Describe the stages of this process.



Your answer:

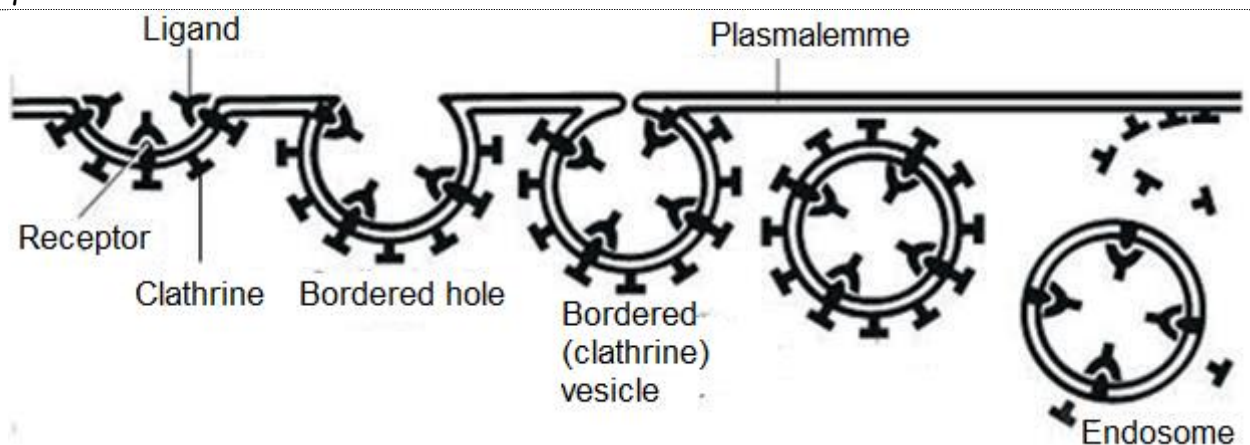
Stages of the process:

For reference: A ligand is a chemical compound (atom, ion, molecule) that forms a complex with a protein (for example, a cellular receptor).

Clathrin belongs to the so-called coat proteins (COP - coated proteins).

Clathrin binds to receptor proteins on the cytoplasmic side and deforms the cell membrane so that a hemispherical structure is formed - a pit.

Receptor-mediated (or specific) endocytosis is endocytosis in which membrane receptors bind to molecules of the absorbed substance (ligands). Receptor-mediated endocytosis allows cells to absorb specific substances.

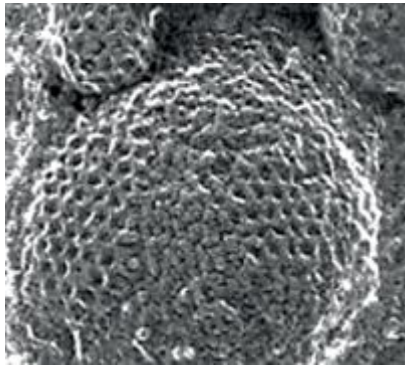


Stages of receptor-mediated endocytosis:

- ✓ Formation of clathrin-coated pits.
- ✓ Invagination of pits into the cell and formation of vesicles.
- ✓ Detachment of vesicles from the membrane.
- ✓ Coated vesicles quickly lose their coat (clathrin returns to the plasmalemma and can be reused)

by the cell for endocytosis), and "naked" endocytotic vesicles in the cytoplasm merge with each other, forming larger vesicles – endosomes. Endosomes, in turn, merge with primary lysosomes, resulting in the formation of secondary lysosomes. In secondary lysosomes, the process of digestion of captured particles occurs with the formation of residual bodies, which are then pushed out of the cell by exocytosis.

Clathrin vesicle



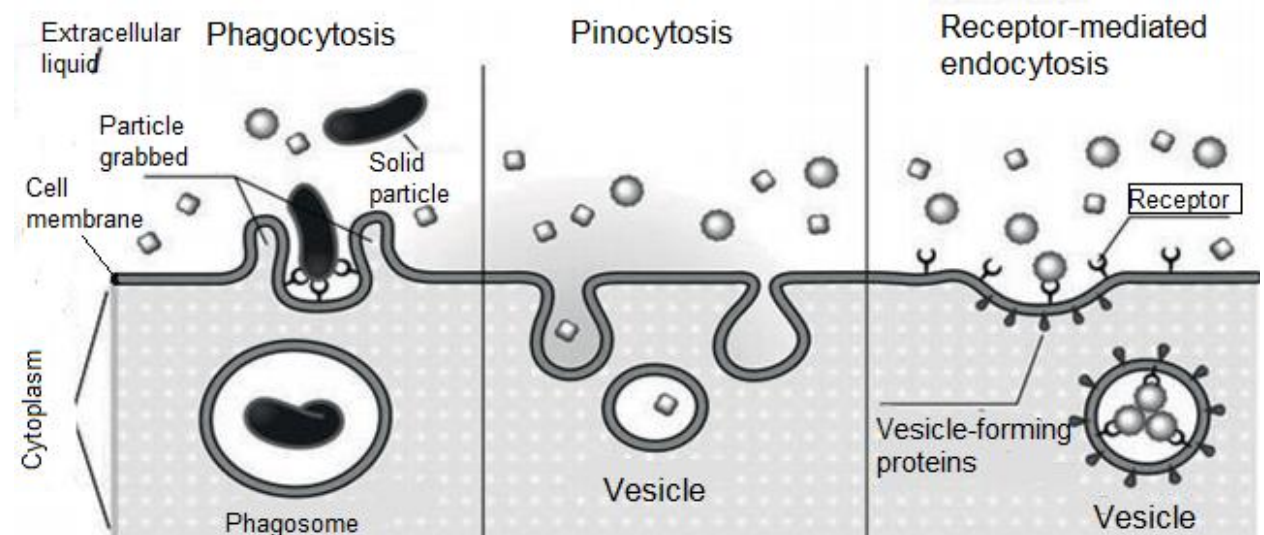
Clathrin vesicle

Examples of receptor-mediated endocytosis: Yolk granule proteins are synthesized in various tissues and then enter the ovaries with the blood flow, where they bind to special membrane receptors of oocytes and enter the cell through endocytosis. Yolk granules are deposited in oocytes.

Other examples: absorption of cholesterol, many bacteria (phagocytosis of a bacterium by a leukocyte), and viruses.

Work 8.3. Specific and non-specific endocytosis

Using the diagram, explain how specific (receptor-mediated) endocytosis differs from nonspecific endocytosis?



Your answer:

Stages of the process:

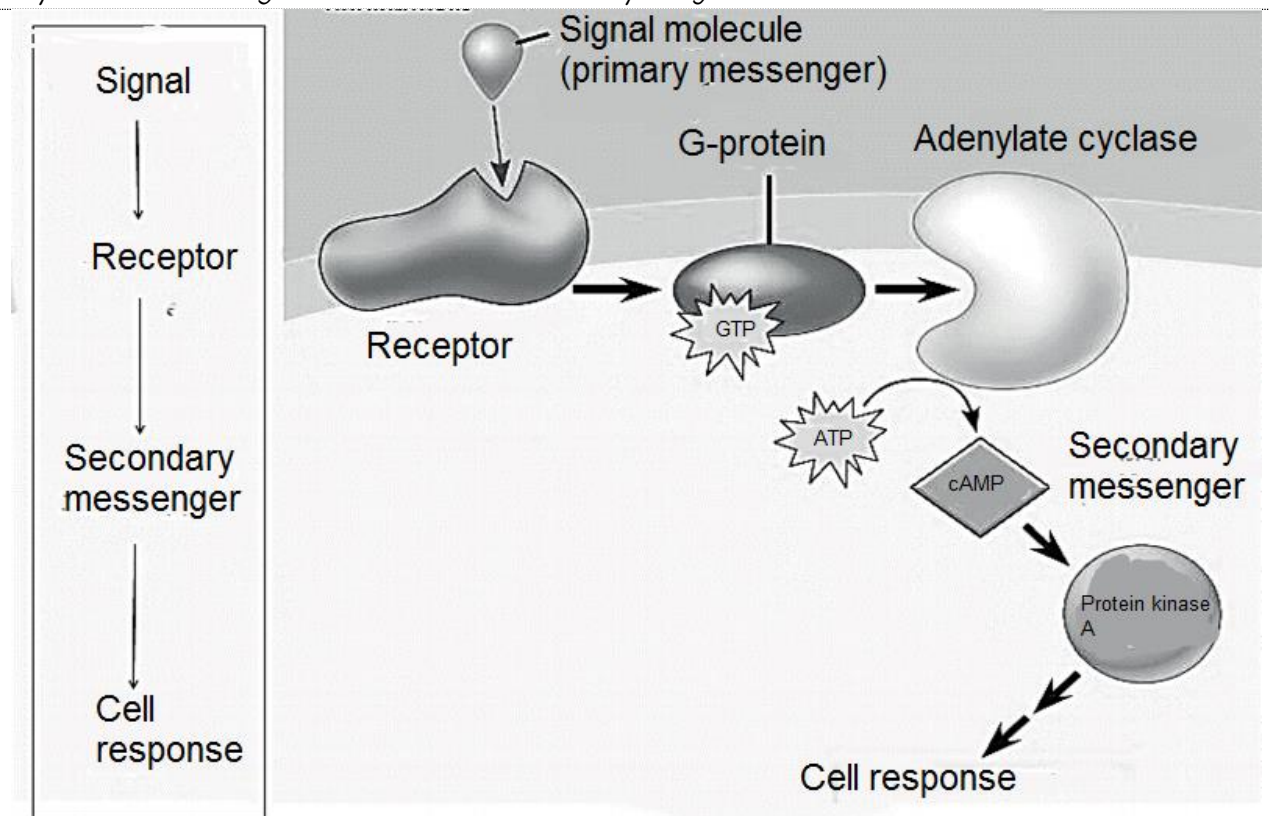
Give examples of substances that are absorbed through specific endocytosis.

Your answer:

Work 8.4. Action of glucagon

The pancreatic hormone glucagon serves as an external signal for hepatocytes (liver cells) about the need to release glucose into the blood due to the breakdown of glycogen. By stimulating the breakdown of glycogen, glucagon helps maintain blood glucose at a constant level.

Task: Using the diagram, using the example of the action of glucagon on a liver cell, describe step by step the scheme of signal transmission from the hepatocyte membrane inside the cell.



Your answer:

1)

2)

3)

4)

For reference: *G*-proteins are a family of regulatory proteins belonging to GTPases and functioning as secondary messengers in intracellular signaling cascades.

Primary messenger (hormone) – a signaling molecule specifically interacting with a membrane receptor

Secondary messengers, or mediators, are intracellular substances whose concentration is strictly controlled by hormones, neurotransmitters and other extracellular signals

Protein kinase A activates and inactivates enzymes through phosphorylation

GTP – Guanosine triphosphate – is a purine nucleotide. It takes part in signal transduction reactions (binds to *G*-proteins)

Scheme of signal transmission to cells using some hormones that include peptide chains: signal-receptor-secondary messenger-response.

Reaction sequence:

- ✓ hormones bind to specific receptors on the surface of the cell's plasma membrane.
- ✓ Receptors, after binding to the hormone, activate the *G*-protein, which already lies in the cytoplasmic part of the plasma membrane,
- ✓ Through the mediation of the *G*-protein, the enzyme adenylate cyclase is activated.
- ✓ Adenylate cyclase is an enzyme that synthesizes a molecule of cyclic AMP from ATP.
- ✓ The role of cyclic AMP (cAMP) is that it is a secondary messenger (mediator) – an activator of enzymes – kinases that cause modifications of protein enzymes in the cell cytoplasm.

Grade for the class _____

Teacher's signature _____

Date _____

Date: _____

TOPIC 9: CELL LIFE CYCLE. MITOSIS.

INDEPENDENT STUDENT WORK

Task 9.1 Give definitions for the terms:

Cell life cycle -	
Mitotic cycle -	
Mitosis -	
Amitosis -	
Endomitosis -	
Interphase -	

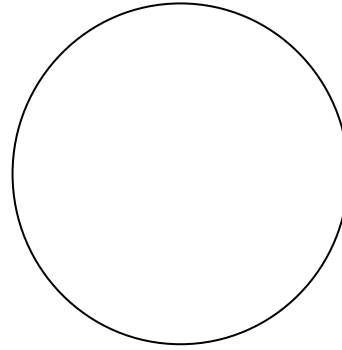
<i>G0 period -</i>	
<i>G1 period -</i>	
<i>S period -</i>	
<i>G2 period -</i>	
<i>Cell differentiation -</i>	
<i>Morphogenesis -</i>	
<i>Apoptosis -</i>	
<i>Necrosis -</i>	
<i>Stem cells -</i>	

Telomerase -

Task 9.2 Draw a diagram of the cell life cycle. Indicate the set of chromosomes (n) and the amount of DNA (c)

The diagram should indicate:

- 1) G_0
- 2) G_1
- 3) S
- 4) G_2
- 5) differentiation
- 6) apoptosis



1. Enter the correct answer

How many DNA molecules will each chromosome contain at the end of interphase? In the answer, write only the corresponding number.

ANSWER _____

2. Enter the correct answer

How many chromosomes are contained in a cell in the prophase of mitosis if there are 80 chromosomes in the original cell? In the answer, write only the corresponding number.

ANSWER _____

3. Enter the correct answer

How many nucleotides are included in a fragment of a double-stranded DNA molecule if it contains 16 nucleotides with thymine and 16 nucleotides with cytosine? In the answer, write only the corresponding

number.

ANSWER _____

4. Enter the correct answer

How many chromosomes does the nucleus of a diploid cell contain if the gamete of an organism of this species has 21 chromosomes? In the answer, write only the corresponding number.

ANSWER _____

5. Enter the correct answer

How many sex chromosomes does a human sperm contain if the haploid set is 23 chromosomes? In the answer, write only the corresponding number.

ANSWER _____

6. Enter the correct answer

The number of autosomes in a rabbit egg is 21. How many sex chromosomes does a rabbit egg contain? In the answer, write only the number of chromosomes.

ANSWER _____

7. Enter the correct answer

How many sex chromosomes does a mammalian somatic cell contain if the diploid set contains 78 chromosomes? In the answer, write only the corresponding number.

ANSWER _____

8. Enter the correct answer

A chicken's somatic cell contains 78 chromosomes. How many sex chromosomes does this cell contain? In the answer, write only the corresponding number.

ANSWER _____

9. Enter the correct answer

The number of chromosomes of a crayfish zygote is 116. How many chromosomes does a cell of the crayfish green gland contain? In the answer, write only the number of chromosomes.

ANSWER _____

10. Enter the correct answer

How many DNA molecules does each chromosome contain before mitosis? In the answer, write only the corresponding number.

ANSWER _____

11. Establish the correspondence and enter the answer.

Establish a correspondence between the processes and phases of mitosis: for each item given in the first column, select the corresponding item from the second column

PROCESSES	PHASES OF MITOSIS
A) Sister chromosomes diverge to the cell poles	1) anaphase 2) telophase
B) Chromosomes despiralize	
C) Nuclear envelope is formed	
D) Spindle fibers are destroyed	
E) Centromeres of chromosomes separate	

Write the selected numbers in the table under the corresponding letters:

A	B	C	D	E

ANSWER _____

12. Establish a correspondence between characteristics and phases of mitosis: for each item given in the first column, select the corresponding item from the second column.

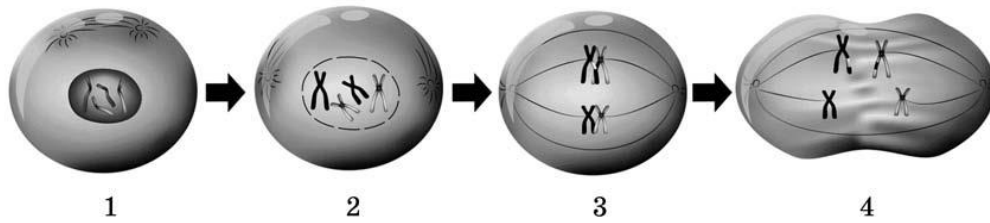
CHARACTERISTICS	PHASES OF MITOSIS
A) Chromosomes consist of two chromatids	1) metaphase 2) telophase
B) Chromosomes despiralize	
C) Spindle fibers attach to the centromere of chromosomes	
D) Nuclear envelope is formed	
E) Chromosomes line up in the equatorial plane of the cell	
F) The disappearance of the spindle fibers occurs	

Write the selected numbers in the table under the corresponding letters:

A	B	C	D	E	F

ANSWER _____

Examine the diagram and complete tasks 5 and 6



No. 13. What number indicates the phase of meiosis, the violation of which processes forms a genomic mutation?

ANSWER _____

No. 14. Establish a correspondence between the characteristics and the processes indicated in the diagram above. For each item given in the first column, select the corresponding item from the second column.

CHARACTERISTIC OF PROCESSES	PHASE MEIOSIS
A) divergence of homologous chromosomes	1) 2 2) 3 3) 4
B) conjugation of chromosomes	
C) crossing-over of chromatids	
D) arrangement of pairs of homologous chromosomes on the equator of the cell	
E) non-homologous chromosomes gather at the cell poles	

Write the selected numbers in the table under the corresponding letters:

A	B	C	D	E

15. Establish the sequence of processes of the cell cycle. Write the corresponding sequence of numbers in the table.

- 1) duplication of centrioles
- 2) spiralization of chromosomes
- 3) divergence of sister chromosomes to different poles
- 4) arrangement of chromosomes in the equatorial plane
- 5) disappearance of spindle fibers

ANSWER _____

16. Establish the sequence of processes of interphase and mitosis. Write down the corresponding sequence of numbers.

- 1) divergence of sister chromatids to opposite poles of the cell
- 2) cell growth
- 3) spiralization of chromosomes
- 4) DNA replication
- 5) formation of two new cells

ANSWER _____

Task 9.3 Situational tasks:

Task 1. In the S-period of the mitotic cycle, DNA and chromosomes double.

Why does the amount of DNA double, but the number of chromosomes does not change? At what stage of the cycle does the number of chromosomes in the cell double?

Your answer:

Task 2. In most somatic cells, the set of chromosomes and DNA is $2n2c$. However, in some cases, intensively working cells must have more genetic material. What are the possible mechanisms for increasing the amount of DNA or chromosomes in a cell?

Task 9.4 Fill in the table: "Functions of some genes controlling the cell cycle and participating in the process of mitosis"

<i>Genes</i>	<i>Functions</i>
<i>Proto-oncogenes</i>	
<i>Oncogenes</i>	
<i>Suppressor genes</i>	
<i>p53 gene</i>	

Task 9.5 Fill in the table: "Functions of some proteins controlling the cell cycle and participating in the process of mitosis"

<i>Proteins</i>	<i>Functions</i>
<i>Growth factors (platelet, epidermal and others)</i>	
<i>Cyclins (A, B, D, E)</i>	
<i>Cyclin-dependent kinases (1, 2, 4, 6)</i>	
<i>Tubulin</i>	
<i>Condensin</i>	
<i>Cohesin</i>	
<i>Motor proteins (dynein, kinesin)</i>	
<i>Contractile proteins (actin, myosin)</i>	

Task 9.6 Fill in the table: "Medical significance of apoptosis".

Indicate diseases associated with impaired apoptosis processes. Suggest principles of action on the mechanisms of apoptosis, allowing the prevention and treatment of these diseases.

<i>Apoptosis disorders</i>	<i>Diseases</i>	<i>Principles of prevention and therapy</i>
<i>Excessive activation of apoptosis</i>		

Blocking of apoptosis		
For reference: Disruption of the mechanisms of apoptosis causes congenital malformations, is the cause of neurodegenerative, myodystrophic and many other diseases. Activation of apoptosis in ischemia and hypoxia, in the zone of minor cell damage in strokes and heart attacks, leads to excessive cell death and increased severity of diseases. Conversely, blocking apoptosis preserves damaged and infected cells, impairs the elimination of cells with genetic abnormalities, causing an increase in genetic instability. Disruption of apoptosis mechanisms is one of the key processes of carcinogenesis and the development of malignant tumors. Knowledge of the molecular processes of apoptosis makes it possible to develop methods of targeted action on its mechanisms. This opens up opportunities for the prevention, treatment and facilitation of rehabilitation in various diseases.		

Task 9.7 Give an explanation of the mechanism of incomplete separation of the II and III toes.

	Your answer:

CLASSROOM WORK

Work 9.1 Mitosis in onion root cells (mitosis in *Ascaris* egg)

Procedure:
Examine the division zone on a microslide at a magnification of x40. Find cells in the interphase stage

and in various phases of mitotic division.

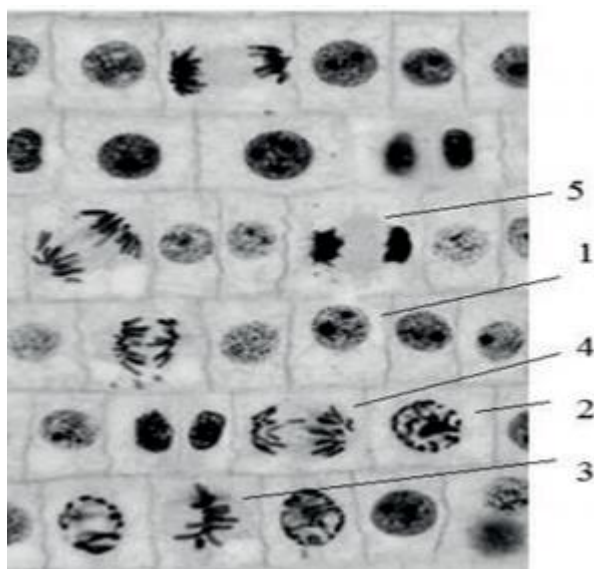
Interphase. The nucleus in the cell is rounded, with clear boundaries. 1 or 2 nucleoli are visible in it.

Chromatin in the form of clumps of varying density fills the karyoplasm.

Prophase. The nucleus increases noticeably, the nucleoli disappear in it. Spiralizing chromosomes become visible in the microscope as thin thread-like structures. At the end of prophase, the nuclear envelope breaks down.

Metaphase. Chromosomes consisting of two chromatids are located in the equatorial plane.

Anaphase. Two groups of sister chromosomes (former chromatids) are visible in the cell, moving to opposite poles. **Telophase.** At opposite poles of the cell, two groups of despiralizing chromosomes are visible, around which the nuclei of daughter cells begin to form. A septum forms in the center, which gradually divides the mother cell into two daughter cells.



Cells of the division zone of the onion root: 1 - interphase; 2 - prophase; 3 - metaphase; 4 - anaphase; 5 - telophase.

Task: Draw cells at various stages of mitosis and in interphase.

The figure should indicate:

- 1) prophase (chromosomes);
- 2) metaphase;
- 3) anaphase;

4) telophase (forming nuclei of daughter cells); 5) interphase (nucleus, cytoplasm, chromatin) Indicate the number of chromosomes (n) and the amount of DNA (c) in these cells.	
Interphase __n__c X600	
Prophase __n__c	Metaphase __n__c
Anaphase __n__c	Telophase __n__c

Work 9.2 Answer the task questions:

What are the key regulatory proteins that trigger and control the processes of the mitotic cycle (interphase and mitosis) in all eukaryotes called?

Your answer:

What is the mechanism of activation of these proteins?

Your answer:

Work 9.3 Fill in the table: "Cell populations, characteristics, examples"

<i>Cell populations</i>	<i>Characteristic</i>	<i>Examples</i>
<i>Stable</i>		
<i>Growing</i>		
<i>Renewing</i>		
What are the genes controlling cell reproduction called: 1 - activating, 2 - blocking:		
1 -		
2 -		

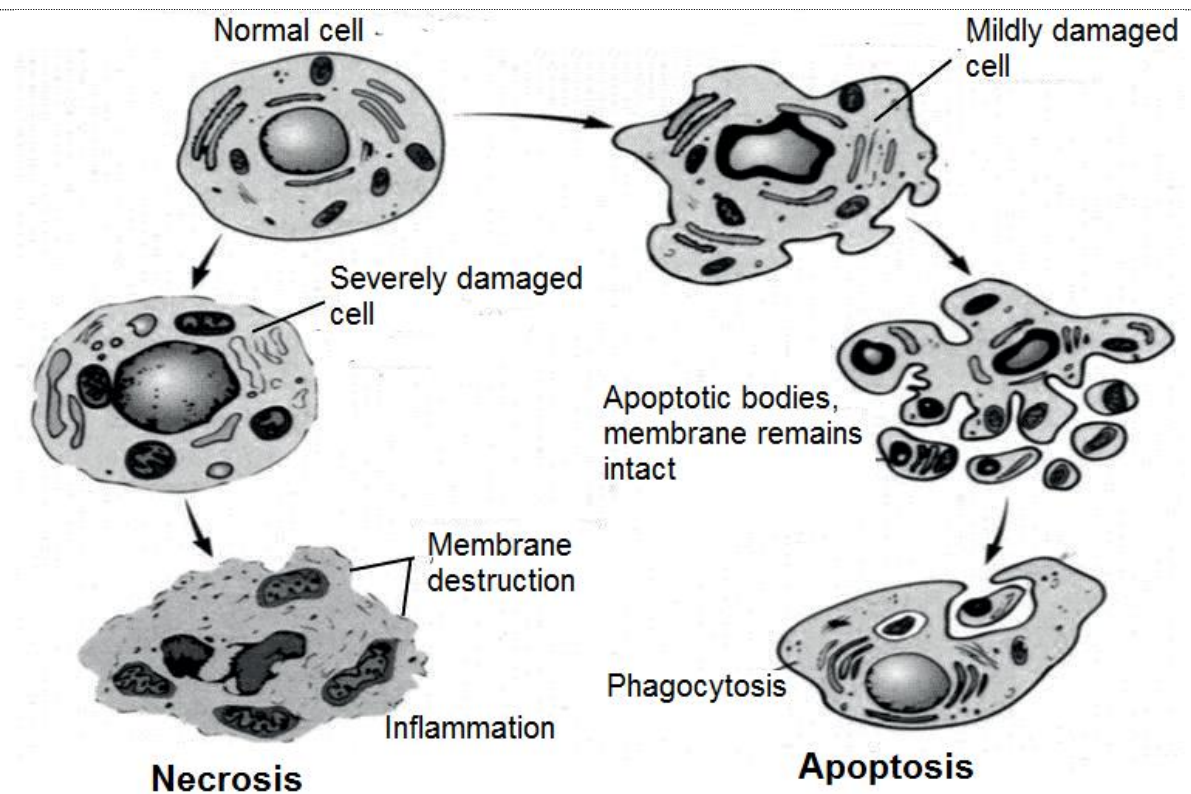
Work 9.4 Fill in the table: "Comparative characteristics of apoptosis and necrosis"

<i>Characteristic</i>	<i>Apoptosis</i>	<i>Necrosis</i>
<i>Genetic control</i>		
<i>Method of cell destruction</i>		
<i>Involvement of adjacent tissues (inflammation)</i>		
<i>Inducing signal (internal or external)</i>		

Examples

For reference:

Significance of apoptosis: 1. Morphogenesis during the development of organisms - destruction of excess cells during organ formation (hand) 2. Maintenance of normal structure of organs and tissues - destruction of terminally differentiated cells, maintaining the balance of cells in renewing tissues 3. Destruction of "stray" cells during their migration from "home" 4. Removal of damaged cells: - with DNA damage (genetic homeostasis) - infected (viruses, etc.) - tumor cells 5. Cell death with a lack of growth factors, nutrition, oxygen and others



CONSOLIDATION

1. The experimenter isolated stem cells at the stage of the presynthetic period (G1), stimulated their division, and then stopped the experiment at the anaphase stage of mitosis. How will:

- A) the number of chromosomes change,
 - B) the number of chromatids change,
 - C) the number of DNA molecules change after stopping the experiment relative to its beginning?
- For each quantity, determine the corresponding nature of its change:
 (1) increased, (2) decreased, (3) did not change.
 Numbers in the answer can be repeated.

ANSWER: ____

2. The experimenter isolated stem cells at the stage of the presynthetic period (G1), stimulated their division, and then stopped the experiment at the anaphase stage of mitosis. How will:

- A) the number of chromosomes change,
 - B) the number of chromatids change,
 - C) the number of DNA molecules change after stopping the experiment relative to its beginning?
- For each quantity, determine the corresponding nature of its change:
 (1) increased, (2) decreased, (3) did not change. Numbers in the answer can be repeated.

ANSWER: ____

3. Establish a correspondence between processes and periods of interphase:

1) postsynthetic, 2) presynthetic, 3) synthetic.

Write numbers 1, 2, 3 in the order corresponding to the letters.

- A) cell growth
- B) synthesis of ATP for the division process
- C) synthesis of ATP for replication of DNA molecules
- D) synthesis of proteins for building microtubules
- E) DNA replication

ANSWER: ____

4. Establish a correspondence between the stages of the cell life cycle and processes occurring during them: 1) interphase, 2) mitosis. Write numbers 1 and 2 in the order corresponding to the letters.

- A) the spindle apparatus is formed
- B) the cell grows, active synthesis of RNA and proteins occurs in it
- C) cytokinesis occurs
- D) the number of DNA molecules doubles
- E) chromosome spiralization occurs

ANSWER: ____

5. Establish the sequence of processes occurring in a cell with chromosomes in interphase and subsequent mitosis

- 1) arrangement of chromosomes in the equatorial plane
- 2) DNA replication and formation of double-chromatid chromosomes
- 3) spiralization of chromosomes
- 4) divergence of sister chromosomes to the poles of the cell
- 5) formation of the spindle apparatus

ANSWER: ____

6. Establish the sequence of processes occurring in interphase and in mitosis. Write down the corresponding sequence of numbers.

- 1) dissolution of the nuclear membrane
- 2) DNA replication
- 3) destruction of the spindle apparatus
- 4) divergence of single-chromatid chromosomes to the cell poles
- 5) formation of the metaphase plate

ANSWER: ____

7. Establish the sequence of processes occurring with chromosomes during mitotic cell division. Write the corresponding sequence of numbers in the table.

- 1) division of centromeres
- 2) divergence of chromosomes to the cell poles
- 3) spiralization of chromosomes
- 4) despiralization of chromosomes
- 5) attachment of spindle fibers to centromeres

ANSWER: ____

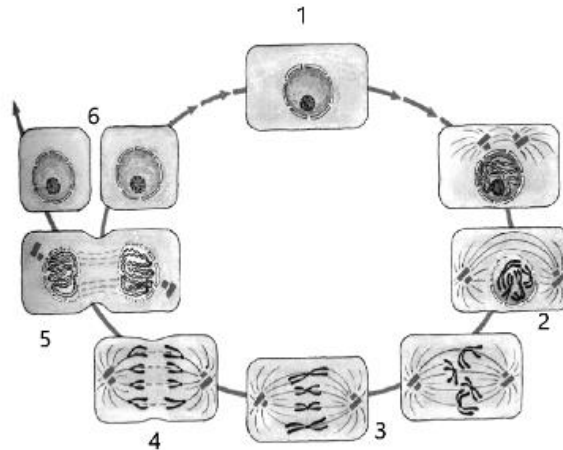
8. Establish a correspondence between processes and phases of the cell life cycle, indicated in the figure 1-4. Write numbers 1-4 in the order corresponding to the letters.

- A) formation of daughter cells
- B) formation of double-chromatid chromosomes
- C) active cell growth
- D) spiralization of chromosomes
- E) active synthesis of tubulin protein
- F) DNA replication

ANSWER: ____

9. Establish a correspondence between the processes and the phases of the cell cycle indicated by numbers 1-4 on the diagram. Write these numbers in the order corresponding to the letters.

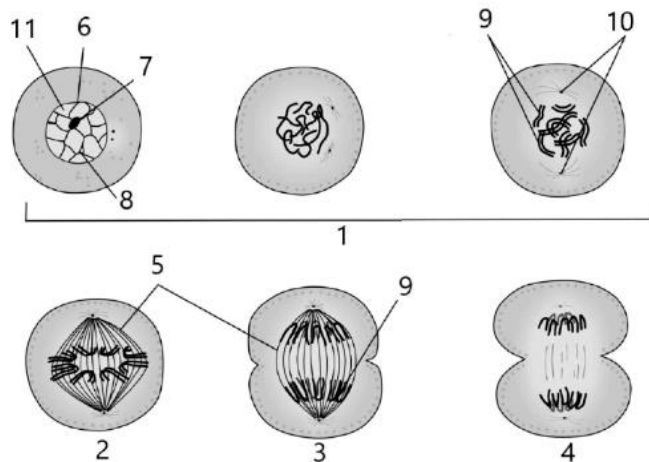
- A) disintegration of the nuclear envelope
- B) accumulation of proteins, nucleotides, lipids
- C) movement of chromosomes to the equator region
- D) doubling of the cell center
- E) divergence of sister chromatids
- F) DNA replication



ANSWER: ____

10. Establish a correspondence between characteristics and phases of mitosis, indicated by numbers 1, 2, 3, 4 in the figure above. Write numbers 1–4 in the order corresponding to the letters.

- A) each chromatid becomes an independent chromosome
- B) the nucleolus disappears
- C) chromosomes align along the equator of the cell
- D) follows interphase
- E) the chromosome set of the cell is $2n2c$
- F) decondensation of chromatin occurs

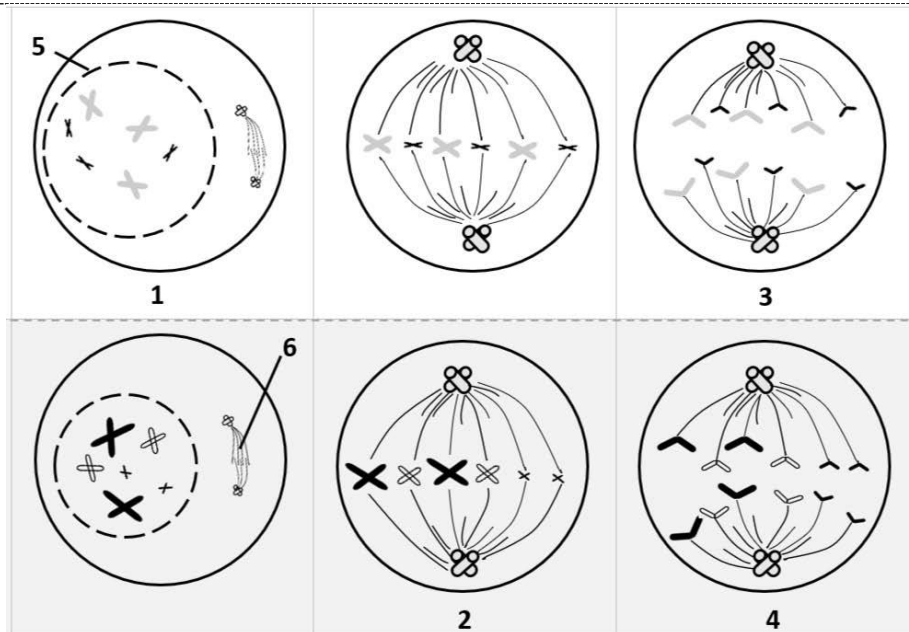


ANSWER: ____

11. A diploid set of chromosomes is characteristic of an animal somatic cell. What is the set of chromosomes and DNA molecules in cells at the end of the synthetic period of interphase? Write down two numbers in the order specified in the task, without separators (spaces, commas, etc.).

ANSWER: ____

What number in the figure indicates the structure consisting of tubulin?



ANSWER: _____

Establish a correspondence between characteristics and phases of mitosis of different cells: for each item given in the first column, select the corresponding item from the second column.

CHARACTERISTIC	PHASE OF MITOSIS
A) dissolution of the nucleus occurs	1) 1 2) 2 3) 3
B) metaphase plate is formed	
C) the chromosome set in the cell is $6n6c$	
D) the chromosome set in the cell is $2n4c$	
E) anaphase of a cell that cannot enter meiosis	
F) metaphase of a diploid cell	

Write the numbers under the corresponding letters.

ANSWER

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TOPIC 10: MEIOSIS

INDEPENDENT STUDENT WORK

INDEPENDENT STUDENT WORK

Task 10.1 Give definitions for the terms:

Bivalent -	
Conjugation -	
Crossing over -	
Gametes -	
Oogenesis -	
Spermatogenesis -	
Fertilization -	

Task 10.2 Fill in the table: "Comparative characteristics of mitosis and meiosis (schematically draw the phases indicating the genetic set for $2n = 4$)"

Characteristics of interphase and division phases	Mitosis	Meiosis	
		I division	II division
Interphase			
Prophase			
Metaphase			
Anaphase			
Telophase			

Task 10.3 Fill in the table: "Comparison of asexual and sexual reproduction"

Feature	Asexual reproduction	Sexual reproduction
1. Number of individuals involved in reproduction		
2. Genetic material of offspring		
3. Recombination of genetic material		
4. Significance for selection		
5. Advantages		
6. Disadvantages		
7. Methods		
8. Examples of organisms		

1. Enter the correct answer

How many DNA molecules are contained in the cell nucleus at the end of telophase of the second meiotic division if the diploid set contains 44 chromosomes? In the answer, write only the corresponding number.

ANSWER _____

2. Enter the correct answer

How many chromosomes are contained in a cell in prophase of the first meiotic division if the diploid set contains 80 chromosomes? In the answer, write only the corresponding number.

ANSWER _____

3. Establish the sequence.

Establish the sequence of processes occurring during meiotic cell division. Write the corresponding sequence of numbers in the table.

- 1) formation of four cells with a haploid set of chromosomes
- 2) divergence of single-chromatid chromosomes to the poles of cells
- 3) divergence of homologous chromosomes to the poles of cells
- 4) crossing over between homologous chromosomes
- 5) conjugation of two-chromatid chromosomes

ANSWER _____

4. Establish the sequence.

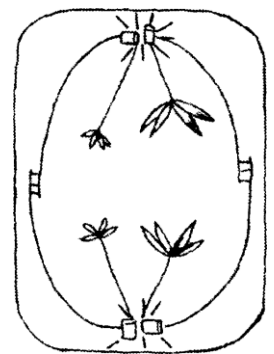
Establish the sequence of processes occurring in meiosis. Write the corresponding sequence of numbers in the table.

- 1) division of centromeres and divergence of sister chromatids
- 2) exchange of segments between homologous chromosomes
- 3) conjugation of homologous chromosomes
- 4) divergence of homologous chromosomes to the poles of the cell
- 5) formation of four cells with a haploid set of chromosomes

ANSWER _____

5. Choose three correct answers out of six and write the numbers under which they are indicated in the table. Which of the following features refer to the phase of meiosis shown in the figure?

- 1) chromosome bivalents are located at the cell equator
- 2) homologous chromosomes consisting of two chromatids diverge to opposite poles
- 3) daughter chromatids diverge to opposite poles of the cell
- 4) reduction in the number of chromosomes occurs
- 5) chromosome set in the cell $n2c$ at each pole of the cell
- 6) the spindle apparatus is formed



ANSWER _____

Source: Kirilenko, 2022, Q5

6. Establish the sequence of processes of the first division of meiosis. Write the corresponding sequence of numbers in the table:

- 1) divergence of two-chromatid chromosomes to different poles
- 2) divergence of centrioles to the cell poles
- 3) formation of pairs of homologous chromosomes
- 4) formation of nuclear envelopes of haploid nuclei

- 5) location of bivalents in the equatorial plane
- 6) initial formation of the mitotic spindle

ANSWER _____

7. Establish the sequence of processes of meiosis. Write the corresponding sequence of numbers in the table.

- 1) divergence of sister chromatids to opposite poles of the cell
- 2) formation of haploid cells with two-chromatid chromosomes
- 3) formation of chromosome bivalents
- 4) alignment of chromosomes in a haploid set in the equatorial plane of the cell
- 5) divergence of chromosomes from bivalents to opposite poles of the cell

ANSWER _____

8. Establish the sequence of processes of the first division of meiosis. Write the corresponding sequence of numbers in the table.

- 1) divergence of two-chromatid chromosomes to different poles
- 2) divergence of centrioles to the cell poles
- 3) formation of pairs of homologous chromosomes
- 4) formation of nuclear envelopes of haploid nuclei
- 5) location of bivalents in the equatorial plane
- 6) initial formation of the mitotic spindle

ANSWER _____

9. Establish the sequence of processes in the life cycle of a eukaryotic cell. Write the corresponding sequence of numbers in the table.

- 1) chromatin condensation
- 2) centriole duplication
- 3) active biosynthesis of proteins
- 4) template synthesis of daughter DNAs
- 5) chromosome condensation

ANSWER _____

10. Establish the sequence of meiosis processes. Write the corresponding sequence of numbers in the table.

- 1) divergence of two-chromatid chromosomes to opposite poles of the cell
- 2) conjugation and crossing-over
- 3) distribution of bivalents in the equatorial plane
- 4) formation of cells with a set of chromosomes and DNA nc
- 5) formation of two haploid cells

ANSWER _____

11. Establish the sequence of processes of meiosis. Write down the corresponding sequence of numbers.

- 1) divergence of sister chromatids to the poles

- 2) formation of two haploid nuclei
- 3) divergence of two-chromatid chromosomes to the poles
- 4) formation of nuclei with a set of chromosomes and DNA nc
- 5) formation of bivalents

ANSWER _____

12. Establish the sequence of processes of interphase and meiosis I. Write down the corresponding sequence of numbers.

- 1) cell growth
- 2) divergence of two-chromatid chromosomes to the cell poles
- 3) DNA replication
- 4) formation of two haploid nuclei
- 5) conjugation and crossing over

ANSWER _____

13. Establish the correct sequence of events occurring during interphase and meiosis. Write down the corresponding sequence of numbers.

- 1) spiralization of chromosomes
- 2) formation of gametes
- 3) DNA replication
- 4) formation of bivalents
- 5) divergence of two-chromatid chromosomes to the poles

ANSWER _____

Task 10.4 Fill in the table: "Characteristics of mammalian testis and ovary cells in the process of gametogenesis"

Period of the life cycle	Name and location of cells		Chromosome set (n)	Amount of DNA (c)
	Testis	Ovary		
Interphase				
Mitosis				
Meiosis I (prophase)				
Meiosis II (prophase, metaphase)				

Differentiated gametes				
------------------------	--	--	--	--

Task 10.5 Fill in the table: "Differences between somatic and sex cells"

Feature	Somatic cell	Sex cell
1. Chromosome set		
2. What division is the basis of formation		
3. Ability to divide		
4. Place of localization		

Task 10.6 Fill in the table: "Differences between male and female sex cells"

Feature	Female cell	Male cell
1. Cell name		
2. Formed in the process of		
3. Size and quantity		
4. Mobility		
5. Shape (in humans)		
6. Reserve nutrients		
7. Place of formation		
8. Beginning of gametogenesis in ontogenesis		

Work 10.7 Situational tasks:

Task 1. In humans, the chromosome set is 46. Determine the number of chromosomes and DNA molecules in spermatogenesis cells at the end of telophase of meiosis I and in anaphase of meiosis II.

Your answer:

Task 2. In humans, the chromosome set is 46. Determine the number of chromosomes and DNA molecules in spermatogenesis cells before the start of division, in metaphase of meiosis I and meiosis II.

<i>Task 3. The haploid set of Drosophila contains 4 chromosomes. Determine the number of chromosomes and DNA molecules in cells during oogenesis in anaphase of meiosis I and prophase of meiosis II.</i>

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Date: _____

TOPIC: 11 EUKARYOTIC CELL. ORGANELLES: NUCLEUS**INDEPENDENT STUDENT WORK****Task 11.1. Give definitions for the terms:**

Karyotype -	
Chromatin -	
Chromosome -	
Histone -	
Nucleosome -	
Solenoid -	
Euchromatin -	
Heterochromatin -	
Barr body -	
Polyteny -	

Basic level test tasks**1. What features of chromosomes ensure the transmission of hereditary information?**Answer:

- 1) chromosomes contain DNA;
- 2) after DNA replication, chromosomes become double-chromatid (contain two identical DNA molecules);
- 3) during cell division (mitosis), chromatids are evenly distributed among daughter cells.

2. The appearance of a diploid set of chromosomes in organisms played a very important role in the evolution of the organic world. Provide at least three consequences of this global aromorphosis. Justify your answer.

Answer:

- 1) duplicated hereditary information made organisms more viable, since random harmful recessive

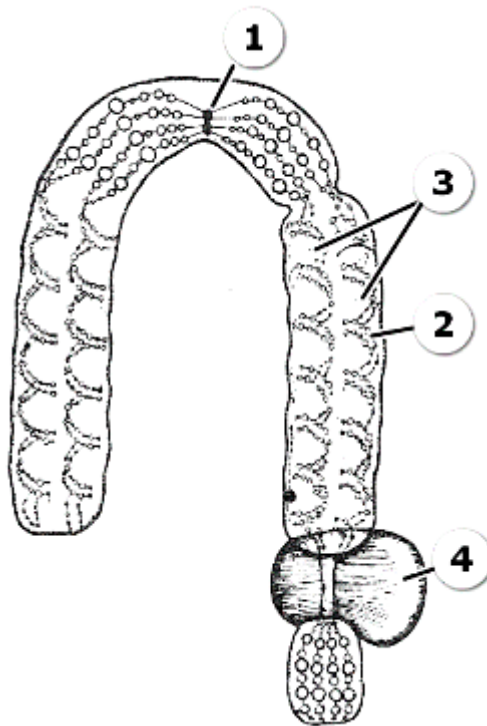
mutations did not lead to the death of cells and organisms;

2) in diploid cells, recessive mutations were preserved as a reserve of hereditary variation and natural selection;

3) diploidy led to the emergence of a new type of cell division – meiosis;

4) diploidy contributed to an increase in the number of gene combinations during meiosis and sexual reproduction, which led to the genetic diversity of organisms.

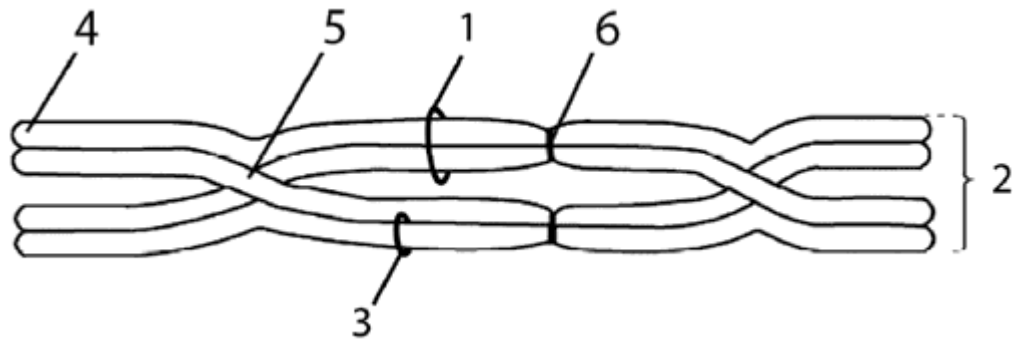
3. Establish a correspondence between the characteristics and chromosome structures indicated by numbers 1, 2, 3, 4 in the figure: for each item given in the first column, select the corresponding item from the second column.



- A) damage can lead to a genomic mutation
- B) chromatids
- C) one of the spirally twisted DNA molecules
- D) is formed at the site of the secondary constriction
- E) synthesis of ribosomal RNAs
- F) attachment site of spindle fibers

Answer: _____

4. Establish a correspondence between the characteristics and elements of the bivalent indicated by numbers 1, 2, 3 in the figure. Write the indicated numbers in the order corresponding to the letters.



- A) is located at the cell equator during metaphase of the first meiotic division
 B) will move to the pole in anaphase of meiosis I division
 C) is formed as a result of conjugation
 D) at the end of the second meiotic division it will become an independent chromosome
 E) contains two DNA molecules
 F) consists of two homologous chromosomes

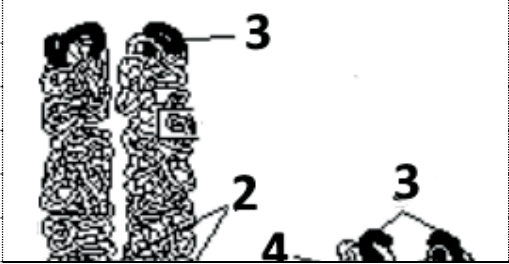
Answer: _____

Task 11.2 Determine and describe the level of genetic material compactization

LEVEL	DIAGRAM
A	
B	
C	
D	

E	
F	
Your answer:	
A -	
B -	
C -	
D -	
E -	
F -	

Task 11.3 Describe the structure and functions of the chromosome. Name the types of chromosomes and label them

Your answer:	
1 -	
2 -	
3 -	

No. 1. What number indicates the substance that transmits information to ribosomes?

ANSWER _____

No. 2. Establish a correspondence between the substances shown in the figure above and their features. For each item given in the first column, select the corresponding item from the second column.

FEATURES OF SUBSTANCES	SUBSTANCES
A) contains an anticodon	1) 1
B) carries information about protein structure	
C) interacts with anticodons on ribosomes	
D) connects with an amino acid	2) 2
E) has sense and transcribing parts	
F) possesses antiparallelism	3) 3

Write the selected numbers in the table under the corresponding letters:

A	B	C	D	E	F

Grade for the class _____

Teacher's signature _____

Date _____

List of Main Literature:

1. The cell. A molecular approach / Geoffrey M. Cooper, Robert E. Hausman - Boston University. – 2018. – 847 p.

List of Additional Literature:

1. Research methods in molecular and cell biology : учебное пособие / А. F. Fakhardo, S. A. Ulasevich, A. Y. Prilepskii, V. V. Vinogradov. — Санкт-Петербург : НИУ ИТМО, 2021. — 52 с. — Текст : электронный // Лань : электронно-библиотечная система. — URL: <https://e.lanbook.com/book/283658>
2. Review questions on cell biology and genetics for students : учебно-методическое пособие / N. S. Abdukaeva, N. S. Kosenkova, T. I. Gracheva [и др.]. — Санкт-Петербург : СПбГПМУ, 2019. — 32 с. — ISBN 978-5-907065-95-6. — Текст : электронный // Лань : электронно-библиотечная система. — URL: <https://e.lanbook.com/book/174468>
3. Гистология по Жункейре. Учебное пособие. Атлас. Издательство ГЭОТАР-Медиа, 2022

**MINISTRY OF SCIENCE AND HIGHER EDUCATION
RUSSIAN FEDERATION**

**FEDERAL STATE AUTONOMOUS EDUCATIONAL INSTITUTION OF
HIGHER EDUCATION
NORTH-CAUCASUS FEDERAL UNIVERSITY**

Methodological Guidelines
for Students on arranging and performing independent work
in the Discipline of Biology:Cytology
for Students majoring (Specialty) in 31.05.01 General Medicine

Methodological Recommendations for Studying Theoretical Material

When performing the independent study of theoretical material, the student must follow the rules as set below. The working curriculum of the respective academic discipline shall be recommended to be used as the basis for such activity. According to the schedule of classroom lessons and independent work, a different number of hours is to be allocated for studying individual topics. A significant portion of the student's independent work should be allocated to mastering the material on the covered topic, writing a summary (notes) on the specified theoretical blocks, and searching for additional literature based on the NCFU library and via the Internet system. The lecture material shall not cover all theoretical material; the greater part of it must be mastered through independent work. Given the above, working with the recommended literature is mandatory. Special attention must be paid to the content of the main provisions and conclusions, the explanation of phenomena and facts, and the understanding of the practical application of the theoretical issues under consideration. In the process of this work, the student should strive to understand and memorize the main provisions of the material being considered, the examples illustrating it, as well as to understand the illustrative material. Preparation should be completed by drawing up a plan (summary/notes) on the material (issue) being studied. This allows for the creation of a concentrated, concise representation of the issues being studied. First, studying the recommended literature is to be done. Special attention must be paid to the content of the main provisions and conclusions, the explanation of phenomena and facts, and the understanding of the practical application of the theoretical issues under consideration.

During this work, the student should strive to understand and memorize the main provisions of the material being considered, the examples illustrating it, as well as to understand the illustrative material. Preparation should be completed by drawing up a plan (summary/notes) on the material (issue) being studied. This allows for the creation of a concentrated, concise representation of the issues being studied. If necessary, one should seek (advice) consultation from the instructor. When going to a consultation, it is necessary to thoroughly think through the questions that require clarification. Keeping records contributes to turning reading into an active process, mobilizing motor memory along with visual memory. The following should be born in mind: a student who systematically keeps records creates their own individual stock of auxiliary materials for a quick review of what has been read and for the mobilization of accumulated knowledge. Records are especially important and useful when they reflect the thoughts that arose during independent work.

It is important to develop the students' capacity to compare sources and to think through the material being studied.

Improving note-taking skills among students is of great importance.

The instructor may recommend the following main forms of recording to students: a plan (simple and detailed), excerpts, and theses (abstracts).

The results of note-taking can be presented in various forms.

- A plan is an outline of the read material, a brief (or detailed) list of questions reflecting the structure and sequence of the material.
- A detailed plan fully replaces a summary.
- A summary (notes) is a systematized, logical presentation of the source material. Four types of summaries are distinguished:
 - Outline-summary (Plan-notes) – this is an expanded, detailed plan in which sufficiently detailed records are provided for those points of the plan that need explanation.
 - Textual summary – this is the reproduction of the most important provisions and facts of the source.
 - Free summary – these are clearly and briefly formulated (stated) main provisions resulting from a deep understanding of the material. It may contain excerpts, quotations, and theses; part of the material may be represented by a plan.
 - Theme-based summary – this is compiled on the basis of studying a number of sources and gives a more or less exhaustive answer according to a certain scheme (issue).

Methodological Guidelines for the Preparation for Practical Activities

When preparing for practical activities, the recommendation implies studying the control questions for the given lesson and the theoretical material from one's own notes.

The main form of work during the lessons is an interview (discussion). Each student must be ready to speak on all issues raised in the plan and demonstrate maximum activity during their consideration.

The speech must be constructed freely, convincingly, and with arguments. The instructor ensures that the speech is not reduced to a reproductive level (simple reproduction of the text); simple reading of the summary is also not allowed.

It is necessary for the speaker to show their own attitude towards what they are talking about, express their personal opinion and understanding, substantiate it, and be able to draw the correct conclusions from what has been said. In doing so, the student may refer to the entries in the summary, directly to the primary sources, use knowledge of previously studied disciplines, etc. In addition, to obtain a grade at an advanced level, students solve situational tasks based on the results of the mastered topics.

During the execution of practical works, a defense of practical skills is provided, the full list of which is specified in the fund of assessment tools.

Methodological Recommendations for the Preparation of Presentations and Reports

The report must contain elements of novelty; along with the fundamental aspect, an analysis of the current state of the problem under study must be carried out, as well as inclusion in regional issues. The report must include an introduction, a theoretical part, a conclusion, a list of literature, and a presentation that reveals the essence of the topic in graphs, pictures, diagrams, and formulas.

The report is recommended to be submitted on 1 printed sheet. The text of the work must be printed with 1.5 line spacing on one side of a standard sheet (A4) of white paper.

The text and other printed elements of the work must be black, and the contours of letters and signs must be clear, without halos and shading. The font must be Times New Roman, size 14. The titles of chapters and paragraphs are highlighted in bold. The sheet with text must have margins: left – 30 mm, right – 10 mm, top – 20 mm, bottom – 20 mm.

Page numbering of the text is done in the lower right corner of the sheet. It is necessary to number pages starting from the page where the Introduction is printed, on which the number 3 is placed. After that, all pages, including appendices, are numbered.

A space equal to two intervals is placed between the title of the chapter and the title of the paragraph of this chapter, and the title of the paragraph must not be separated from the text of this paragraph by a space. The titles of paragraphs shall be separated from the text of the previous paragraph by a space equal to two intervals. Each chapter, as well as the introduction, conclusions, appendices, and the list of used literature, begin on a new page. The word Chapter is not to be written. Chapters have ordinal numbers within the entire work, designated by Arabic numerals (for example: 1, 2, 3), followed by a period.

The word **PARAGRAPH** or the paragraph symbol (§) is not placed in the title. Paragraphs have ordinal numbers within the chapters, designated by Arabic numerals (for example: 1.1. and 1.2.).

Headings of chapters and paragraphs in the text must be centered; a period shall not be placed at the end of the title of the chapter and paragraph. It is not allowed to hyphenate (transfer) a part of a word in a heading. 4.5. The numbering of tables and figures can be running (continuous) or relate to the number of the chapter and paragraph. For example, if a table or a figure is included in the text of the first paragraph of the second chapter, the numbering is as follows: Table 2.1.1., Fig. 2.1.1.

The last digit means the ordinal number of the table (or figure) in this paragraph.

The table is to be placed as the next page after the first mention of it in the text.